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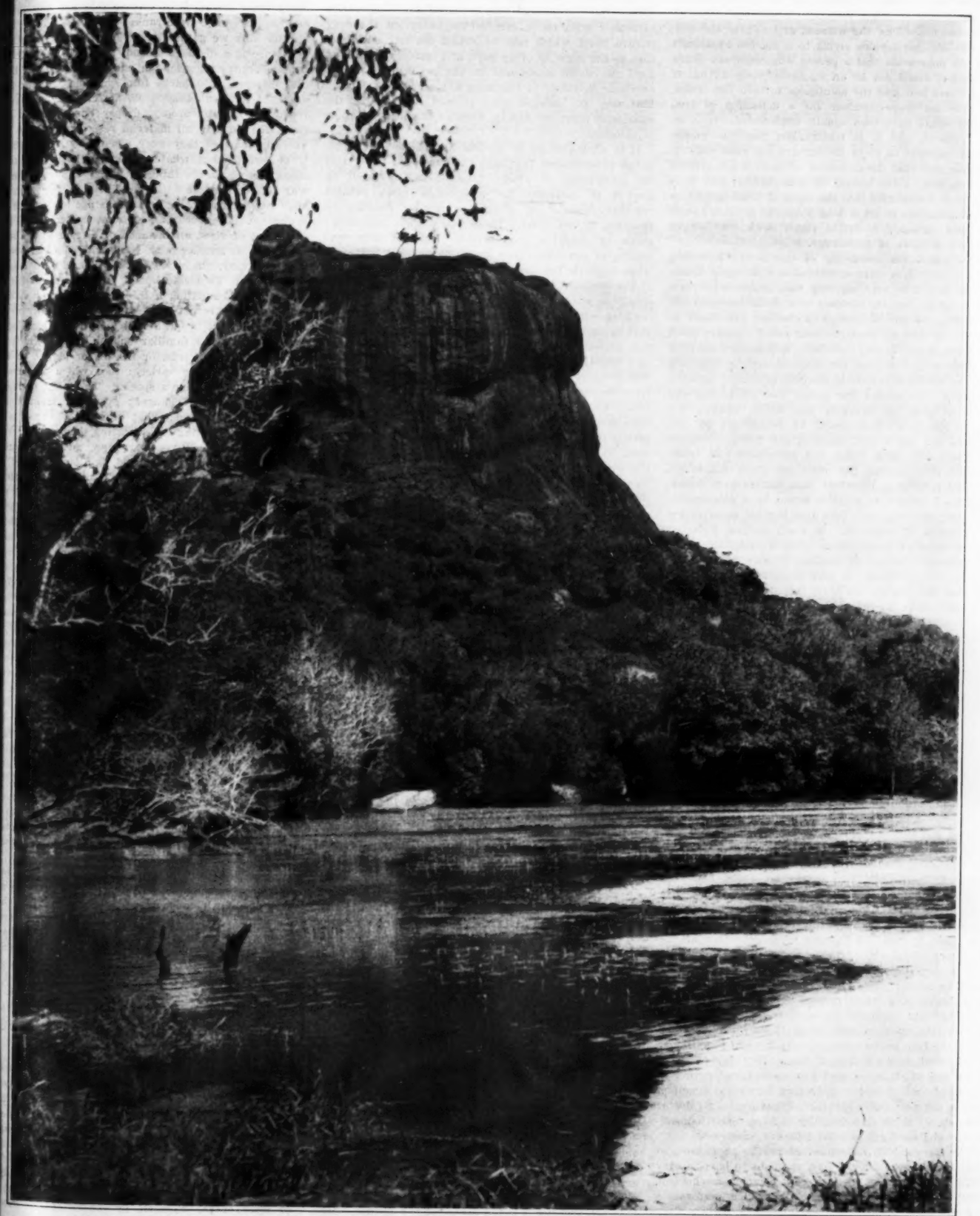


The Rock of Sigiri. The ancient capital of Ceylon was located on the four acres on the top of this rock, and a spiral roadway led to its top

THE ANCIENT CAPITALS OF LANKA—[See page 152]

What Is a Disease*

An Attempt to Formulate Definitions of the Fundamental Concepts of Medicine

By Charles Mercier, M.D., F.R.C.P., F.R.C.S.

A GENERATION or two ago it used to be a favorite dodge of counsel to begin their cross-examination of a witness who claimed to be an expert in mental diseases, by asking him to define insanity. The dodge was well calculated to confuse the witness, and to take the conceit out of him; besides giving to a not too intelligent jury the impression that a person who could not define his subject could not be an authority upon it; but if the witness had had the astuteness to turn the tables, and ask his cross-examiner for a definition of law, counsel would have been equally confounded. It is, in fact, evident, and it is remarkable, that the fundamental concepts in every calling are the most difficult to define, and that the definition of them is not arrived at until late in the history of that calling; and it is even more remarkable that the want of valid definitions of fundamentals is for a long time but little felt, and does not seriously interfere either with practice or with the advance of knowledge.

If a committee consisting of the Lord Chancellor and all the judges were appointed to draw up a definition of law it is very unlikely that any two of them would agree; but the absence of a definition does not embarrass the administration of the law. It would be as hard to find an engineer who could frame a good definition of matter and force as to find another engineer to agree with him; but the want of such a definition does not hinder engineers in building bridges or devising machines. No soldier can define war, no parson can define religion, no financier can define finance, nor any merchant what is meant by commerce; but yet soldiers can make war, parsons can preach religion, financiers can raise loans, and merchants can trade, without ever feeling the want of these definitions. It is not surprising, therefore, that doctors have formulated no definition of what is meant by a disease, nor that the want of such a definition has not embarrassed the practice of medicine. In every calling, however, a time must at length come when a definition of its fundamental concepts is needed; it may be to divide it from other callings; it may be to settle some question that lies near the boundary line; it may be for some purpose foreign to the calling itself. Such a time is now arrived in the history of medicine.

Owing to enactments casting upon other than injured or sick persons the burden of their treatment and maintenance, and of compensating the dependants of those who are killed, there has grown up a great amount of litigation about medical matters; and as all decisions in law turn upon the meaning of some word of phrase, it is not surprising that much of this litigation turns upon the meaning of such words as injury, accident, disease, functional disease, organic disease, imaginary disease, and so forth. It was natural that law should turn to medicine for definitions of these terms, terms that are used daily and hourly in medicine, and without which the science and art of medicine could not be carried on; and law must have been considerably surprised to find that medicine has been using these terms for centuries without any clear formulation of their meaning, a surprise which was no doubt none the less for the fact, which law did not recognize, that some of its own fundamental terms, such as motive and intention, were equally wanting in definite formulation. The time is now come when some definition of the fundamentals of medicine must be found. The definitions that I shall propose may not be perfect, but at least they do render more clear the fundamental concepts of medicine that are at present nebulous and inchoate, and they are supported by reasons that it is open to any one to question and refute if they are unsound. From the tyro to the veteran, every medical practitioner speaks and thinks scores of times every day of symptoms and of diseases, and has some vague notion in his mind that there is a difference between a symptom and a disease; but what that difference is, no doctor can tell. I think this inability is a reproach to medicine, and I shall try in what follows to remove it.

The human body, as conceived by the physician and the surgeon—the alienist has, or ought to have, a very different concept of it—is a very complex mechanism, composed of many parts, each of which performs a certain duty toward the whole, and a certain duty toward itself. These duties or actions are called the *functions* of the part, and according as the duty is well or ill performed, the function is normal, or defective, or disordered. The duty toward the rest of the body, which may be termed the extrinsic function, varies extremely with the nature of the part; but the duty toward itself, which may be termed the intrinsic function, is the same in every part, and consists in making good the waste consequent on the performance of its extrinsic function, in repairing any structural damage that may be inflicted upon it, and in repelling the attacks of injurious agents, whether chemical, microbic or cellular.

It is often debated by novices in medicine—of established practitioners few have the time, and fewer still the inclination, to ponder general questions—but by novices in medicine the question is often debated whether disorder of structure precedes disorder of function, or *vice versa*. Those who discuss this matter mean by function the extrinsic function only, and whichever conclusion they arrive at will not hold good when intrinsic function is taken into the consideration. If the intrinsic function is disordered or defective, the structure must fall into disrepair, and be unable to perform with full efficiency its extrinsic function; so that in such a case, while disorder of (intrinsic) function precedes disorder of structure, disorder of structure precedes disorder of (extrinsic) function. Even with respect to extrinsic function alone, the answer must depend on the meaning that is attached to structure. The (extrinsic) function of a part is seriously interfered with or abolished if the blood supply of that part is seriously diminished or abolished; but the structure, in any usual, and I think proper, meaning of the word structure, cannot be impaired, for the function is resumed as soon as the blood supply is reëstablished.

However this may be, it often happens that from one cause or another the function, either intrinsic or extrinsic, of a part of the body is disordered or defective. It is imperfectly performed; and when this happens there is usually, perhaps always, some sign or manifestation of the altered performance of function. The sign may be perceptible to the patient alone, as in the case of pain or deafness, or dimness of vision, or a whoreson tingling; or, like coma, it may be perceptible to bystanders only; or, like a cardiac murmur, or fluctuation, or optic neuritis, it may not be perceptible except to the skilled examination of the physician; or it may, like cough, vomiting, swelling, and other deformity, be perceptible both to the patient himself and to others. It may be, like a barking cough or an elephantic leg, gross as a mountain, open, palpable; or it may be, like want of sensitiveness in a pupil, or diminution of a knee-jerk, so slight that we can scarcely be sure that it is present. It may, like a cavity in a tooth or a phlyctenule on the eye, show unmistakably what function of what part is disordered; or it may, like headache, give no indication whatever; but in every case in which function is disordered, some sign or manifestation of the disorder is perceptible to some one; and such a sign or manifestation is called a *symptom*. This, then, is the definition of a symptom. It is a sign or manifestation of disorder of the function, intrinsic or extrinsic, of some part of the body.

Disease is a wide and comprehensive term, covering not only all disorders of function, and all symptoms, or signs of disordered function, but also all results of disorder of function, whether the function disordered is intrinsic or extrinsic. Thus, indigestion, which is disorder purely of extrinsic function, is disease: atrophy, which is disorder purely of intrinsic function, is disease: albuminuria, which is a result of disorder of extrinsic function, is disease: a lardaceous liver or a cancerous breast, which is a result of disorder of intrinsic function, is disease: pain, which may be a manifestation of disorder of either intrinsic or extrinsic function, is disease.

So far all is plain sailing, and I do not think any one will object to anything that has been said; but when we modify the term by the addition of the article, and speak of "a disease" we are at once entangled in a thicket of difficulties. Pain is disease; but it is not, at least it is not necessarily, a disease. Albuminuria is disease; but it is not a disease. Hæmatemesis is disease; but it is not a disease, at least it is not now considered, though there was a time when not only hæmatemesis, but cough, hæmaturia, albuminuria, vomiting, dropsy, palsy, jaundice, syncope and many other instances of disease that are now ranked as symptoms only, were ranked as diseases.

From this we gather, first that not everything that is disease is a disease; second, that there is some difference between a symptom and a disease; and third, that diseases may change into symptoms. Since, however, the things themselves do not change, but a cough remains a cough; dropsy, dropsy; and syncope, syncope; the same in all material respects now that they are symptoms as they were when they were diseases, it is certain that whatever change has taken place, since it is not in the things themselves, must be in our way of contemplating them. There is no other possible way of accounting for the change of diseases into symptoms. Regarded in one way, contemplated from one point of view, an instance of disease is a disease. Regarded in another way, contemplated from another point of view, the same instance of disease becomes a symptom. To medical men, the difference that the mode of contemplating a thing makes in our estimate of that thing is not very familiar, and may appear startling; but it is quite well known to psychologists, and instances are familiar enough. That which was once a species of birds, or insects, or plants, or what not, is now a mere variety: that which was once a variety is now become a species. The birds, or insects, or plants, are not changed: even our knowledge of them is not changed: what alone is changed is our way of contemplating or estimating them. The reverend philosopher of our youth is now a self-opinionated dogmatist. He is not changed, but our mode of contemplating him is changed. We may look upon the sea as a barrier between nations, or we may look upon it as a means of intercourse between nations. The sea has not changed, but our mode of contemplating it has changed. So when a disease becomes a symptom, it is not the thing that is changed: the change is solely and entirely in our estimate of it; and therefore the question, What is the difference between a symptom and a disease? is resolved into the question, What is the difference in our mode or standard of estimating an instance of disease that determines us to call that instance a symptom instead of calling it a disease?

What our method or point of view is in contemplating it as a symptom we have already discovered. In so contemplating it, we contemplate it as a sign or manifestation of disorder of function. What is the point of view from which we regard the very same occurrences when we call them diseases and regard them as disease? How do we contemplate them and estimate them? That is the problem that we are to solve.

Before we can attack this problem with success, we must settle certain preliminaries and clear up certain obscurities; and it will assist us in our task if we show that certain things sometimes called diseases are not diseases.

In the first place, let us note that we always regard a disease as an individual thing. It may include many symptoms, for instance, it may include structural change and damage in internal organs; but these are parts or factors that go to make up the disease, and what we mean by a disease is always an individual thing or whole. We speak of treating the disease; we speak of the disease being fatal; we speak of fluctuation of the disease: we speak of the disease becoming more severe, or less severe: we speak of its beginning and its ending; and in each case the phraseology shows that we regard the disease as an individual thing. The use of the article alone is conclusive of this.

It is unnecessary to show that a symptom is not a disease, is not at any rate necessarily a disease, for this is the thesis with which we started; but it may be advisable to show that structural disease, deteriorating change of structure, or structural damage, is not a disease. It is advisable to show this because we often speak as if structural damage of an organ were a disease. If we ask what disease a patient is suffering from, and are told that it is inflammation of the lung, or ulcer of the stomach, or cancer of the liver, we accept the answer as satisfactory, and are not struck by any incongruity between the answer and the ques-

*Science Progress.

tion. But this is because we do not take the answer in its literal sense. We do not understand it to mean the structural damage alone. An inflamed lung, an ulcerated stomach, or a cancerous liver may exist in a dead body; may be taken out of the body and preserved in spirits; and it will be acknowledged that it would be erroneous and absurd to call the preserved organ a disease. It is a diseased organ, but it is not a disease; and if it is not a disease when taken out of the body, neither is it a disease when it is in the body. If it is not a disease after death, neither is it a disease during life. Yet we speak of ulcer of the stomach as a disease. But when we speak of ulcer of the stomach or any other structural change as a disease, we do not mean what we say. We express ourselves inaccurately. The expression is approximate only, as so many of our expressions are. We do not regard a patient who suffers from ulcer of the stomach merely as a person in whose stomach there is an ulcer, and there end our contemplation of him. We think of him as a person who not only has an ulcer in his stomach, but also suffers the consequences and presents the symptoms of ulcer of the stomach; and it is these additions to the bare structural change that constitute, with that change, the disease from which the patient suffers. There are, in fact, two very different concepts connoted by the names of most damaging changes of structure. The name may mean the structural damage, the ulcer in the stomach, the lumps of cancer in the liver, the consolidation of the lung, and nothing more; and then it is a term in morbid anatomy. It means disease of an organ, or it means a diseased organ; but it does not mean a disease. The name may, however, be employed with the connotation, not only of the structural damage, but also of the consequences, accompaniments, and symptoms of that damage when it exists in the living body, and, so employed, the name of the structural damage does stand, or may stand, for the name of a disease.

It may stand for the name of a disease, but even when it carries the connotation of its consequences and symptoms, the name of a structural damage does not always stand for a disease, at least for the whole of a disease. In the course of acute rheumatism a valve of the heart may suffer structural damage, and this structural damage has its own group of consequences and symptoms. It allows of regurgitation of the blood into the cavity it has just left, it gives rise to a murmur, it causes shortness of breath, cyanosis, œdema, and so forth, all of which are summed up and included in the term "heart disease"; yet this structural damage to the heart, associated though it is in our minds with its consequences and symptoms under the name of heart disease, does not constitute "the disease" from which the patient suffers. The group of structural damage, consequences, and symptoms is an important part of the disease, no doubt, but a part only; for "the disease" is acute rheumatism. Again, from the valve thus diseased a vegetation may be detached, and may block an artery in the brain, causing structural damage to the brain, with its characteristic train of symptoms. The term "embolism of the brain" has, like other names of structural change, its double meaning. It may mean the presence of the block in the artery, or it may mean this together with the consequent disorganization of the brain, or it may mean these things together with the paralysis and other symptoms that are evidence of them; yet, even if the term is understood in the latter sense, embolism of the brain is not the disease, is not the whole disease, from which the patient suffers. His disease is still acute rheumatism, of which the heart disease and the embolism are consequences and parts. If, however, the rheumatism subsides and disappears, leaving the valve of the heart damaged, then this structural damage, plus its symptoms and consequences, becomes the disease from which the patient suffers. We find, therefore, that structural damage to an organ, together with the consequences and symptoms it produces, may constitute a disease, but does not necessarily constitute a disease.

(To be continued)

Reductions of Nitric Oxide by Contact Action of Metals and Metallic Oxides*

By Birendra Bhusan Adhikary

Sabatier and Senderens have studied the direct hydrogenation of nitric oxide in presence of nickel and copper (*Comptes Rendus*, 1902, cxxxv., 278); Negoi and Adhikary have also shown that nitric oxide is reduced to ammonia in presence of reduced nickel (*Zeit. Anorg. Chem.*, 1910, lxix, 209). As the problem is an interesting one, in this paper has been studied the action of hydrogen on nitric oxide in presence of other metals. Sabatier and Senderens have shown that in presence of palladium sponge, previously saturated with hydrogen, nitric oxide is completely converted into water and ammonia (*Comptes Rendus*, 1892, cxiv., 1429). The same authors have also shown that in presence of nickel and copper (*loc. cit.*) water and ammonia are the main products formed. It has been found that ammonia and water are mainly formed in presence of some other metals, but the temperatures at which the reaction commences are different for different metals; but in all cases it has been found that when the reaction once starts it goes on when the temperature is lowered. The only explanation of this seems to be that the action is exothermic and that the heat evolved maintains the action at a lower temperature.

The mixture of nitric oxide and hydrogen was passed over gold, silver, magnesium, tin, lead, antimony, bismuth, and iron. It has been found that the yield of ammonia is greater when the metal is in a fine state of division and is freshly reduced. Sabatier and Senderens have found that oxidisable metals, like copper, iron, cadmium, zinc, are superficially oxidized by nitric oxide, and that the same metals obtained in a fine state of division by reduction in hydrogen are more readily oxidized by nitric oxide (*Comptes Rendus*, 1892, cxiv., 1429). It seems that here, in cases of easily oxidizable metals, they are alternately oxidized and reduced by means of nitric oxide and hydrogen respectively, and that nascent nitrogen combines with excess of hydrogen to form ammonia. But exceptions must be made in cases of gold and silver which are not oxidized by nitric oxide (Sabatier and Senderens, *loc. cit.*).

In cases of metallic oxides tried it has been found that oxides are first reduced to lower oxides or to metals, and these then act as catalytic agents.

GOLD AND SILVER AS CATALYTIC AGENTS

Gold was prepared by reduction of auric chloride by ferrous sulphate. A small quantity of it (not more than 0.01 of a grm.) was heated in a tube in a nitre-bath, and the mixture of nitric oxide and hydrogen in the proportion of 1 to 3 was passed over it. Traces of ammonia began to form when the temperature of the bath was 280° C., and the action became quite perceptible at 290° C. As the reaction is oxothermic the temperature inside the tube could not be strictly controlled. The action was very rapid when the temperature of the bath was kept between 335°-345° C. It was found that the yield of ammonia was almost quantitative when nitric oxide and hydrogen were mixed in the above proportion. When the same mixture was passed over gold-foil it was found that only traces of ammonia were formed.

Silver was prepared by the reduction of silver oxide. The mixture of nitric oxide and hydrogen in the above proportion was passed over reduced silver heated in a tube in a nitre-bath. Traces of ammonia began to form at 390° C., and the action became quite perceptible when the temperature of the bath was raised above 400° C. Instead of silver, silverized asbestos (*i. e.*, asbestos soaked in a solution of silver nitrate and ignited) may be used. Blank experiments performed with asbestos alone showed that only traces of ammonia form when the mixture is passed over ignited asbestos. It was found that the yield of ammonia is quite large when the mixture of gases is passed over silver in the above proportion, the temperature of the nitre-bath being 430° C.

IRON AS A CATALYST

The mixture of nitric oxide and hydrogen in the proportion of 1 to 3 was passed over iron, prepared by the reduction of iron oxide by means of hydrogen and heated in a nitre-bath. Traces of ammonia began to form at 300° C., and the action was very rapid at 350° C.

MAGNESIUM, ZINC, AND MERCURY AS CATALYSTS

The mixture of nitric oxide and hydrogen in the proportion of 1 to 3 was passed over magnesium powders (Merck), heated in a tube-heater; only traces of ammonia were obtained, and the Nessler's solution became only slightly red.

The same mixture was passed over zinc dust (Merck), heated in a tube-heater; ammonia was obtained in large quantities, and the yield was almost quantitative.

When the same mixture was passed over mercury, heated to about 400° C., no ammonia was obtained. It may be noted here that Sabatier and Senderens (*loc. cit.*) have found that mercury vapor is not oxidized by nitric oxide.

ALUMINIUM, TIN, AND LEAD AS CATALYSTS

The mixture of nitric oxide and hydrogen in the proportion of 1 to 3 was passed over aluminum powders (Merck); only traces of ammonia were obtained. When about two litres of the mixture were passed over aluminium Nessler's solution became only slightly red. Here also it may be noted that aluminium is not oxidized by nitric oxide (Sabatier and Senderens, *loc. cit.*).

The same mixture was passed over tin metal powders (Merck) heated in a tube heater; ammonia was obtained in large quantities and the yield was almost quantitative.

The same mixture was passed over lead-foil. Lead melted and ammonia was obtained only in small quantities. It was found that lead powders obtained by the reduction of lead oxide gave better yield of ammonia. In this case it was found that lead, though melted, remained in the form of a number of separate globules. It has generally been found that if the metal be in the liquid state better results are obtained when it is in the form of minute globules; in the latter case it may be noted that the metal presents a larger surface.

ANTIMONY AND BISMUTH AS CATALYSTS

When the mixture of gases was passed over antimony powders (Merck) ammonia was obtained, but larger quantities were obtained when antimony powders were freshly prepared by the reduction of the oxides of antimony by means of hydrogen.

When the same mixture was passed over bismuth metal powdered, bismuth melted and no ammonia was obtained, but when bismuth powders were prepared by the reduction of bismuth oxide and the mixture passed over it large quantities of ammonia were obtained. In this case the metal, though in a liquid state, remained in the form of a number of separate globules.

METALLIC OXIDES AS CATALYSTS

The mixture of nitric oxide and hydrogen in the proportion of 1 to 3 was passed over oxides of metals belonging to Group II of Mendeleeff's Table. When zinc oxide or cadmium oxide were taken large quantities of ammonia were evolved, but in the case of other oxides—*e. g.*, BaO, MgO, etc.—no trace of ammonia was obtained. When mercuric oxide was used it volatilized, and no ammonia was evolved.

When the same mixture was passed over oxides of aluminium, boron, and silicon ammonia was not obtained, but when it passed over oxides of lead, tin, bismuth, and antimony ammonia evolved copiously. In the case of arsenious oxide it volatilized and no ammonia was obtained. When the mixture was passed over oxide of chromium ammonia was produced. When the same mixture passed over oxides of manganese (MnO or MnO_2) ammonia was produced in large quantities. In the case of MnO_2 it was found that the dioxide was converted into yellowish green monoxide during the reaction.

*Chemical News.

An Improvement in the Open-Hearth Steel Making

Many modifications in the the original basic open-hearth process of steel making have attained important results, but in each process the elimination of the impurities in the molten metal has been effected by the refining action of a basic slag floating upon the surface of the metallic bath. The resulting action has of necessity been comparatively slow, as such a limited quantity of the metal to be refined is in contact at any one moment with the basic slag.

With the object of overcoming this difficulty, and thereby shortening the time taken in steel making, a British inventor proposes in patents which he has recently taken out in this country and in the United States, for the refining slag not merely to rest upon the surface of the molten metal, but also to be below the metal. This may be accomplished, it is proposed, by coating the basic bath lining with a layer of highly-heated slag of a rich calcareous and oxidizing nature, which would slowly liquefy when the charge of molten pig was poured upon it. Consequently it would work up through the metallic bath, afterwards continuing its oxidizing and refining action while floating upon the surface.

If it could be carried out practically there sertainly would seem to be something in the idea. The great advantage of innumerable small streams of globules of molten slag rising up through the metal will be at once apparent when it is realised what an immense area of rich oxidizing slag would be exposed with an ever-changing surface to the action of the metal, causing an intensely rapid and searching reaction in a manner somewhat analogous to the action of the air in the Bessemer process.

Though the first charge of molten metal in the suggested process is worked in the usual manner, subsequent charges are worked on new lines, the object being to secure a slag coating on the bottom and sides of the furnace, the latter being preferably of the tilting type, to enable the metal to be poured off and the slag left behind. Thus, after the first charge, on pouring into the steel furnace the usual charge of molten pig-iron from the blast furnace or mixer, a vigorous refining action at once ensues.

Whether all the many claims set out in the patent would be verified as a result of an actual trial remains to be seen. Certainly it would appear that the question, bearing as it does so closely upon the vital subject of speeding up our steel output, deserves more than passing notice.—*The London Daily Telegraph.*

The Use of Iron by Primitive Man*

And the Sources from Which It Was Obtained

METEORITES, as they reach our planet, are of three different kinds, namely, *siderites*, composed chiefly of nickel-iron; *aerolites*, composed chiefly of stony matter; and *siderolites*, composed of a mixture of iron and stone. The first and third only are of interest to us in this inquiry.

Great diversity of opinion has always prevailed among archæologists concerning the source of iron used in antiquity before it was intelligently produced from the ore. On the whole these opinions are about equally divided, though perhaps the majority are inclined to the verdict that meteoritic iron was *not* used by primitive man, for the following reasons: First, because nearly all iron implements of antiquity extant, at least from the Old World (including the piece found in the Great Pyramid of Cheops), are of terrestrial origin; secondly, because it was believed to be non-malleable; thirdly, because it was said to be too scarce; and fourthly, because it was argued that small fragments could not have been detached from meteoritic masses by the means available to primitive man.

There is, to the casual observer, a great deal of truth in these four arguments, and they prove that there were several sporadic sources from which the early iron was drawn; perhaps in one locality they were chiefly terrestrial, while the use of extra-terrestrial or meteoritic iron predominated in other localities.

The fact that iron, in the earliest ages and from whatever source, was extremely rare is beyond all doubt. One might say that it was at least as rare as, and perhaps more valuable than, gold. It might therefore be asked: If meteoric iron was so rare and valuable, why was it not more carefully preserved by the people of antiquity? For, whereas we have plenty of gold objects of ancient workmanship in our museums, those of meteoritic iron are conspicuous by their absence. To this we may safely reply that the value of the meteoritic iron lay in its actual employment in the form of tools, implements, and weapons, and to have hidden such objects in treasure stores would have nullified their value, and that is one reason at least why so few were preserved. This disposes of argument number one.

We must bear in mind also that in the New World this argument does not apply with the same force, as we shall see that objects of meteoritic iron are not so rare there as in the Old World. The reason for this is that, whereas iron was produced in the Old World from the ore more than three thousand years ago, it was not introduced into the New World until the discovery of that continent about four hundred years ago, and it is obvious that objects more than three thousand years old have become rarer in our day than those comparatively new ones of only four hundred years ago.

A paper on this subject was contributed by the present writer at the autumn meeting of the Iron and Steel Institute. One of the principal features of this paper is a table including practically all known falls of meteoritic iron, their original weight, whether malleable (that is, suitable for being wrought into objects of utility) or non-malleable (not suitable for such purposes). This table was compiled with the object of removing all doubt concerning argument number two. The *resumé* of this table gives us the amount of meteoritic iron known at the present day—about 250 tons. Of this total the very considerable amount of more than ninety-nine per cent is malleable. Since this considerable mass of approximately 250 tons has been accumulated practically within the last century, we might dispose of argument number three, concerning the scarcity of meteoritic iron.

This *resumé* cannot be surprising, as meteoritic iron is, generally speaking, pure iron-nickel alloy, such as we are now producing artificially; and the latter is certainly ductile and malleable.

The general appearance of the majority of meteorites gives one the impression that they were fragmentary, and suggests that they formed portions of larger masses. A single fall might spread over a considerable area, and it is obvious that many masses of known falls must thus be difficult to find, or be lost, particularly such smaller pieces as might be wrought into useful objects.

The accompanying illustration (Fig. 1) shows the fragmentary form of a few masses of meteoritic iron, from which we see that it is not like a cannon-ball, as is frequently supposed, and that it should not be so very difficult to sever such fragments. This disposes of argument number four.

Meteoritic iron was cut by the ancients in the same way as they cut pieces off the large masses of native copper found on the banks of Lake Superior, though it is not of course suggested that iron can be cut as readily as copper. When Cortes completed the conquest of Mexico the Spaniards noticed that the Aztecs possessed knives, daggers, etc., made of iron, and the question as to whence they had procured this iron became a perplexing problem to the Spaniards, which they were never

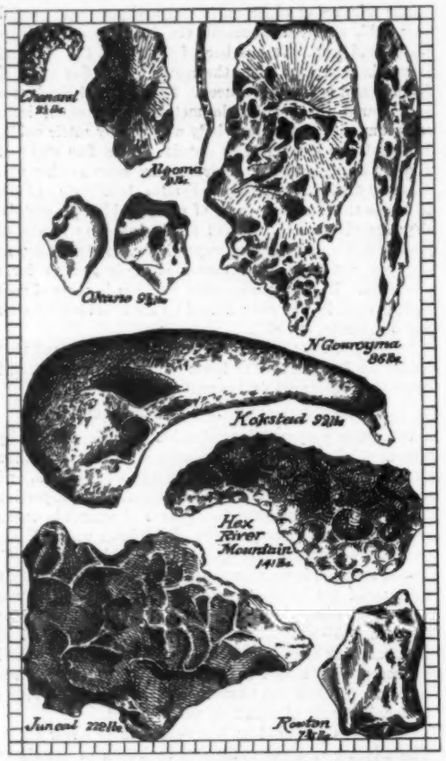
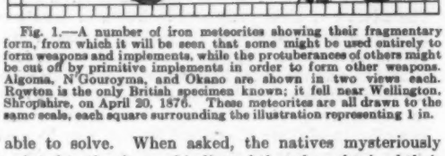


Fig. 1.—A number of iron meteorites showing their fragmentary form, from which it will be seen that some might be used entirely to form weapons and implements, while the protuberances of others might be cut off by primitive implements in order to form other weapons. Algoma, N'Gouroyma, and Okano are shown in two views each. Rowton is the only British specimen known; it fell near Wellington, Shropshire, on April 20, 1876. These meteorites are all drawn to the same scale, each square surrounding the illustration representing 1 in.

able to solve. When asked, the natives mysteriously pointed to the sky, and indicated that they obtained their iron from the regions above. It was left to science to unravel the mystery. The Aztecs were quite correct; the iron of which they had made their implements had

"Oodoo" or women's knife: the handle is of ivory.



"Savik" or man's knife (actual length, 4 in.); the hangle is of wood and bone.

Fig. 2.—Ancient Esquimo knives made from the Melville Bay meteorite found by Rear-Admiral R. E. Peary.

come to them from the unknown regions of space, and was, in fact, of meteoritic origin.

Others, including Eskimos, certain Indian tribes, and the inhabitants of Yakutsk, in Eastern Siberia, used weapons and implements of meteoritic iron.

It would be impossible to mention here, even briefly, all the numerous meteorites of note which have fallen from time to time since the very earliest days. We may mention, however, in passing, the large meteorite which fell in the time of Pindar, 403 B. C., at Ægos Potamos, which is recorded in the Parian Chronicle, engraved in marble; and the stone at Orchomenos, of which Pausanias says that it fell from heaven before the siege of Troy, and during the reign of King Eteocles. Many falls are also mentioned by Pliny. Livy alone mentions twenty-one falls in fifty one years which fell during his lifetime. Another meteorite of note is the stone in the Kaaba, the most sacred jewel of Islam, called "The right hand of God on earth," which was probably worshiped formerly as the temple sacred to the Moon that used to stand in Mecca. These few examples will show how well it was understood in antiquity that meteorites came from an extra-terrestrial source; this is also the reason why, in practically all the languages of antiquity, iron is called "metal of heaven." The author believes that the very word *metal*, from the Greek verb *metallao*—"to search diligently for other things"—has reference to the diligent search which had to be made by the people of antiquity for meteoritic iron, being the "other things" more coveted by them than their usual raw material, namely, stones.

If we compare the mention of meteorites in ancient and modern literature, it would almost seem that meteorites were more plentiful in olden times; for we must bear in mind that when primitive man used iron first, he used it most probably in the same way in which he used copper 8,000 B. C.—that is, for pins and needles, and such other objects in which, for instance, small flakes of iron could be inserted in bone handles, like the knives and other implements of the Eskimos. Where larger masses were used they were probably employed in the same way and form as stone axes and adzes with the haft tied on. Better chisels and knives were probably not made until experience had been gained in the making of needles and pins, and after the use of the smith's fire was understood.

In conclusion we may say that primitive man before 1,200 B. C. used iron more or less sparingly, which iron was obtained from the following sporadic sources:

(a) Iron meteorites.

(b) Chance productions by a camp fire, a flash of lightning, a forest fire, or through volcanic agency.

(c) Telluric or native iron.

We thus see that in using the nickelliferous meteoritic iron primitive man had the advantage of a metal that was not available to modern man until 1809, which is the approximate date at which nickel steel was first manufactured in the modern steel industry.

*From an article by G. F. Zimmer in *Nature*.

A Guilty Basarisk

WHEN Keeper George Snyder found that five of his young mourning doves had been killed in the night by dashing about their cage, he was more than mildly annoyed. Further investigation showed that several domestic pigeons inside the Pheasant Aviary had been killed. It was evident that some creature had been running about the cage-top, with results only too well known to keepers of game birds. The difficulties of rearing birds in captivity are indeed manifold, but nothing is so distrubing as the depredations of vermin.

After some search, an aperture measuring 2 x 3 inches in a skylight shield was found to be decorated with several incriminating hairs. The evidence, however, was of such doubtful nature, that we could not determine the depredator. The hairs were too long for a rat, too pale for a racoon, too curly for an opossum—and anyway, the space in the wire was much too small to admit either of the latter.

There was no time for quibbling in such an emergency, and that night traps of many sorts were set in promising places. The first trap inspected the following morning, one of the box type, held a snarling captive, quite unharmed. But what manner of beast was this, with the bushy, ringed tail of a raccoon, the sinuous body of a marten, and the face and temper of a cat? Gingerly picking up the trap-cage, the captor carried it and its disgruntled inmate to the Small Mammal House, where its advent was hailed with joy. It proved to be a basarisk, or ring-tailed "cat," a carnivorous member of the raccoon family, whose habitat is Texas and Central America. The animal had escaped from its cage nearly three months before. The excellent condition of the culprit proved it to be the perpetrator of many crimes that had been attributed to comparatively innocent rats and raccoons.—*Bulletin of the New York Zoological Society.*

Amateur Astronomical Photography*

An Easily Constructed Camera for the Telescope

By M. Thomas Fullan, Director of the Instrument Section, Alabama Polytechnic Institute

To the amateur astronomer there is nothing more fascinating than the taking of a photograph of a heavenly body. A well rendered drawing made from an observation calls for a high degree of patience, for skill, and for judgment, but a photograph is Nature's own work, eliminating the imagination of the delineator, and attracting even the casual observer. The Sun and the Moon offer the best chances for success, particularly the latter. Stars require such long exposure, and consequent careful and patient guiding, that they tax the endurance of the average amateur to such an extent that it puts them quite out of reach. The writer, who is often called upon by members of the Instrument Section for advice on the construction of telescope accessories, has given much thought to the design of a camera for the telescope that would be efficient and practical, and at the same time easy of construction. There is no difficulty encountered in the design where a well equipped workshop is at hand, and an optician's stock available, and building by a skilled worker, but where the device is to be constructed by an unskilled person, with ordinary tools, and at a small cost, the problem is quite different.

The camera here described presents no great difficulty in construction, and much of it can be obtained from stock. It is of the general type described by Rudeaux, from whom the illustrations are taken. However, some important changes were made by the writer, in order to use film packs instead of plates, and to secure a large image without much enlargement. In Fig. 1 is shown the camera attached to the eye-tube of the telescope. It may be used with or without the eye-piece. The most satisfactory arrangement is to remove the eye-piece, and introduce a negative (double-concave) lens in its place. This will give a much larger image than is obtained without either the eye-piece or the lens. It is possible to get an image large enough to give good detail without an enlargement.

An achromatic negative lens is best for this work, but as these lenses are not usually carried in stock, and must be made up to order, the expense and delay involved will discourage the average worker. An ordinary negative reducing glass, as used by engravers, which is non-achromatic, will serve the purpose very well. In this case, it might be well to introduce a color screen near the focus of the telescope ,of an orange tint, which will improve the photographic image very much. The screen can be made of a piece of photographic gelatine coated film stained orange with aniline dye to the desired tint. Simply take a piece of unexposed sensitized film, and immerse it in "hypo" until cleared, after which process wash it as usual. Then immerse in dye, and dry by pinning up against the edge of a shelf or table, so that the back of the film does not touch the wood.

The material of the camera box can be of thin wood, which is much easier to work than metal with ordinary tools. Cigar-box wood, two thicknesses glued together with grain crossed, makes an excellent material. Remove the paper label and coat with good glue; then clamp or place under a heavy weight until dry. The size of the box will depend upon the size of the photographic plate used. The writer recommends the use of films in film-pack in preference to the glass plate. Film-packs contain twelve exposures and can be easily manipulated; any film can be removed for development without risking the others. Directions come with the film-packs.

The special advantage of the film is that it is doubly coated with gelatine, and prevents to a large extent the halation of the image, which is caused by reflection of the bright image from the back of the plate, blurring the sharpness of the photograph. If plates are preferred by the worker, they should be "backed" before use in the camera. The backing mixture is made up as follows:

Caramel	2 tablespoonfuls
Burnt sienna (powdered)	1 tablespoonful
Alcohol	4 fluid ounces
Water	to make ½ pint

The mixture should be of about the consistency of cream and a slight variation of any of the above ingredients will not affect the action of the backing. Use a piece of cotton wool or a soft sponge for applying the backing to the glass surface of the plate opposite the film side. In about half an hour the coating will be dry enough for use. It is well to coat a number of plates at one time. When developing, first run

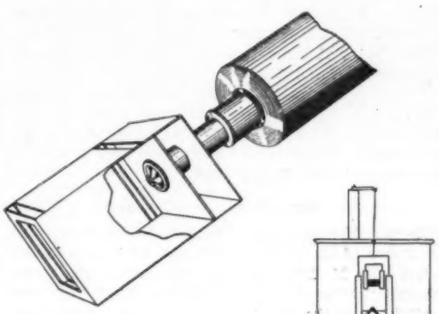


Fig. 1—Camera box attached to telescope (Schematic)

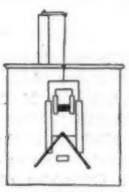


Fig. 2—Plan of shutter

water over the film side, and then wash off the backing; finally, rinse both sides well, and develop as usual. A clear image, free from halo, should be obtained with this backing. Of course, for the Moon, a fast plate should be used, and a slow one for the Sun.

Fig. 3—Method of photographing the moon in the focus of the telescope

The standard sizes of film-packs as carried in stock by all dealers in photographic supplies are as follows:

2¼ x 3¼	1 dozen exposures, 36 cents
2½ x 4¼	1 dozen exposures, 45 cents
3¼ x 4¼	1 dozen exposures, 63 cents

And the film-pack adapters can be obtained also from any dealer in supplies and cost about double what the

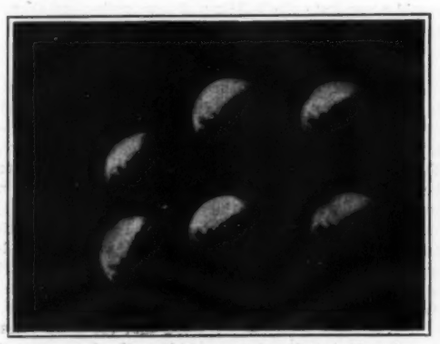


Fig. 4—Unenlarged focal images of the moon in an 8-inch reflector

packs cost. Besides the film-pack adapter, an ordinary plate-holder should be provided, which must be fitted with a piece of finely ground glass for a focusing screen. If the surface of the ground glass is placed in the same position as a plate in the holder, it will occupy the correct place for focusing for exposures. The center partition of the holder should be cut away, leaving about ¼ inch all around to keep the screen in position. A couple of pieces of clock spring will keep the screen holder and the pack adapter in close contact with the box in the manner of simple plate cameras.

The shutter is shown in Fig. 2. It is exceedingly simple and quite effective. It is fitted to the box as shown and reposes in grooves made of strips of tin plate, and should be near the focus of the telescope, either in front of or just behind the negative lens. The frame of the shutter is a piece of thin wood with a hole in the center just large enough to allow the entire cone of light to pass without obstruction. The movable part of the shutter is of thin metal (tin-plate), which slides freely between two guides of the same material, which are crimped and tacked to the wood with small brads. The actuating spring is a piece of rubber band, although a fine coiled wire spring will do quite as well. A loop of thread serves to hold the spring tight and is clipped with a pair of scissors in working the shutter. A number of loops can be made up and one slipped on each time the shutter is operated.

An extension of the box is provided to make it steady; the extension will depend upon the shape of the nose of the eye-tube. The camera should be adjusted just to slip on and off without disturbing any other part of the instrument. When the box has been completed it can be stained and waxed, but a covering of keratol or other imitation leather will improve the appearance of the job. Although this final finish in no way improves the working of the camera, yet it adds much to the looks of it, and the worker feels more pride in the accomplishment of the device and does not hesitate to show it to his friends.

To operate the camera, place the ground glass screen in position, and if the Moon is to be photographed, focus for the best image. Adjust the shutter for the largest opening; this adjustment can be effected by moving the adjusting strip seen in Fig. 2 until it is wide open, about ⅜ inch. The slit can be closed until it is almost a line for the Sun. Now, slip the loop of thread over the hook, and remove the screen, replacing it with the film-pack adapter. Remove the slide, and find the image in the finder; then clip the thread, making the exposure.

It might be well to develop the film at once to determine whether the visual focus and the chemical (photographic) focus correspond. Very often there is a slight difference, and when the location is established the camera can be marked for future work.

The writer has made a number of photographs of the Moon with the eight-inch reflector by simply placing the sensitized surface of the plate against the eye-piece tube without a camera attachment, the eye-piece, of course, being removed. A focusing cloth was adjusted with a piece of wire to prevent the direct rays of the Moon from striking the plate, and a piece of cardboard or a straw hat was used over the mouth of the telescope tube for a shutter. The procedure is as follows: Remove the eye-piece, and place a piece of finely ground glass on the end of the tube, and focus on the object, obtaining a clear image. Now take the sensitive plate out of the box and have the assistant place the cardboard shutter over the mouth of the telescope tube, holding it an inch or two away so as not to disturb the instrument. Place the plate carefully against the tube, as shown in Fig. 3, letting it rest easily in place, and call to the assistant to remove and replace the shutter, with such signals as "*off*" and "*on*." A half second will give a good exposure for the Moon; that is about as fast as the assistant can remove and replace the shutter. I used lantern slide plates, which are fairly fast and are rich in silver; they give rich, contrasty images that enlarge well. In my telescope the image of the Moon is about ¾ of an inch in diameter and can be enlarged to 2½ and 3 inches easily.

A plate 3¼ x 4 (lantern slide) with several exposures taken in this manner is shown in Fig. 4 exact size. Some hundred and fifty such photographs were taken during the progress of the eclipse of the Moon on the night of July 14, 1916. A few were blurred but 80 per cent was satisfactory.

For the Sun, some form of camera is necessary. Besides, a slow, well-backed plate must be used, with a fast shutter, and a fine slit in it. A diaphragm with a small opening of about ½ inch is placed over the mouth of the telescope tube.

*Read before the Third Annual Conference of the Society of Practical Astronomy, and republished from the *Monthly Register* of the Society.

New Railway Lines Projected in Russia*

Proposals for the Development of Transportation and Manufactures

In both belligerent and neutral countries the pressure upon transportation facilities has been so heavy as to create critical situations of the utmost gravity. Nowhere, perhaps, have such crises been so disastrous as in Russia, since her means of transport are utterly inadequate to the demands of modern industry, even in times of peace.

Shortly before the outbreak of the present war the Bureau of Roadways and Communications published a report containing for the first time information on the length of all available roadways; these comprised at the end of 1910 about 1,076,239 versts, a verst being equal to 1,066.781 meters. This corresponds to 57 versts per 1,000 square versts, and to 641 versts per 100,000 inhabitants. Of the total length of roadways, the railroads comprised only 6 per cent; waterways formed 26 per cent; paved highways, 3 per cent, and unpaved roads, 65 per cent. Seventy-five per cent of all these roads were in European Russia.

The immense majority of the waterways could be used only for drifting with the current, instead of for passage in both directions. A more recent report, quoted in *Le Génie Civil*, states that on January 1, 1915, the railway lines comprised 59,000 kilometers in European Russia, and 11,707 kilometers in Asiatic Russia. About 67 per cent of these belonged to the government. To realize Russia's backwardness we need only compare the statistics for other countries: Belgium has 16 kilometers of railroads per 100 square kilometers of territory; England, 12; Germany, 11.7; France, 9.4; Austria-Hungary, 7.

Traffic on Russian lines has increased more rapidly than growth in mileage. The weight of merchandise transported rose from 75,850,000 tons in 1903 to 131,800,000 tons in 1913. The number of passengers increased to 117,527 in 1907, and to 173,533 in 1911.

Expenses for improvement and extension have not augmented in the same proportions. For the government roads they were $39,600,000 in 1908 and $46,400,000 in 1913. The value of new rolling stock for the same lines was $25,400,000 in 1908, $14,300,000 in 1910, $10,000,000 in 1912 and $19,700,000 in 1913.

The financial results are said to have been brilliant, but the chief part of the profits has necessarily been expended to improve the rolling stock or the lines.

THE INFLUENCE OF THE WAR.

After responding fairly well to the demands of mobilization and concentration of the army, the Russian roads continued to operate pretty regularly for some time. But the situation grew suddenly worse in the middle of 1915. The retreat of the army was largely responsible for this, notably by the loss of a large number of terminal stations, and by the necessity of evacuating factories and warehouses in the invaded regions and transporting the refugees. All these things caused a degree of disorganization, which was perhaps augmented by reason of errors on the part of the general direction of the railroads, the Bureau of Roadways and Communications not yet having united into one the activities of the various organizations.

This disorganization, increased by frequent abuses on the part of agents of administration, often created intolerable situations. Thus, enormous reserves of all sorts of merchandise encumbered the freight depots of the roads, where they deteriorated, while large cities and industrial centers, sometimes quite near by, lacked material of prime necessity.

In the basin of the Donetz, nobody knew what to do with the coal which could not be transported, while Russian factories had to shut down for lack of fuel. Many railroad stations refused all merchandise. The movement of travelers, everywhere irregular, was at times completely arrested on the great lines; the mails were irregular—and all this not solely because of the lack of rolling stock but also because of poor utilization of that on hand.

FINANCIAL CONSEQUENCES OF THE ACTIVITY OF THE RAILROADS DURING THE WAR.

Even at the beginning of the war, while the industrial and commercial life of the country was not yet adapted to the new conditions, the gross receipts of the Russian roads were not greatly diminished. Thus, in 1914 the receipts of the private lines were as high as $178,000,000, instead of $176,400,000 of the year before.

As for the government roads, the gross receipts of the Asiatic system remained likewise unchanged ($57,800,000), while that of the European system decreased by $28,000,000. . . . The situation changed only very slightly during the first half of 1915. The receipts of the private lines were $84,000,000, instead of $92,000,000 for the first half of 1914. In the case of the government roads a distinction must be made between the Asiatic and the European systems. While the gross receipts of the first, used for the transport of merchandise and munitions from the Far East, rose from $31,200,000 to $38,000,000, those of the second passed from $190,000,000 during the first semester of 1914 to $160,000,000 during the same period of the following year. The second half of 1915, corresponding to the industrial mobilization, witnessed a sensible increase of gross railroad receipts. This became still more visible in 1916. The receipts of all the Russian railroads during the first quarter of 1916 were $161,000,000, very little less than those of 1914, $165,000,000.

PROJECTED RAILROAD CONSTRUCTION.

The war has once more demonstrated to Russia the importance of an extensive and well equipped railroad system. As M. Migouline has declared in the *Noviy Ekonomist* (*New Economist*) of May 14-27, 1916, the insufficiency of the Russian system "is one of the most important causes of the Russian defeat of 1915 and of the difficulties of provisioning which Russia is now experiencing." Before the war the necessity of elaborating and putting in operation a vast project of railroad construction obliged the Russian government to appoint a special commission for this purpose. The commission recently terminated its labors, and the Council of Ministers proposed to the Duma to allow, during the five years to come (1917-21), under the item of extraordinary expenses, $1,590,000 a year for developing the railroad system in Russia. According to the calculations of the government this should permit the building of 4,000 versts annually. Moreover, the private roads would have to construct 2,000 versts annually. Hence, during the next five years the Russian railroad system should grow at the rate of 6,000 versts per year, at an annual expenditure of $478,800,000.

This vast plan raises two important questions: the effort to obtain the necessary capital, and the adaptation of Russian industry to the execution of such enormous contracts. According to approximate calculations, every 6,000 versts of new railroad lines to be created annually will require 570,000 tons of rails. Repairs and replacements will raise the annual quantity of rails demanded to 885,000 tons. But before the war the Russian works were able to furnish only 573,000 tons per year. The annual demand for joints for the old and new lines comes to 250,000 tons, while their annual production does not exceed 164,000 tons. Forty thousand freight cars are required annually for the existing lines, and 50,000 for the new lines. But the present production in Russia equals only 30,000 cars; 3,000 passenger cars are needed annually, while the car works at present make only 1,300 to 1,600; and 3,000 engines are needed, while production at present has attained only 900. Finally, 150,000 tons of wheel tires are needed yearly, and the present production varies from 40,000 to 80,000 tons. To sum up, the production of the car works should be doubled at least, which would necessitate the building of new works, and therefore the expenditure of considerable capital.

IMPROVED HIGHWAYS WILL BE REQUIRED.

Subsequently it will be necessary to perfect the system of highways, especially of those terminating at new stations, for, according to certain economists, each kilometer of railroad necessitates a kilometer of highways. Furthermore, all this will require special attention to be given to the improvement of technical instruction in Russia. According to the view of Prof. Tiapkine, it is necessary to create at once a third Superior Institute of Roadways and Communications, twenty secondary technical schools for railroads, forty commercial schools, destined to form a body of experienced agents, and finally forty primary technical schools.

It is obvious from the foregoing that the great question is whether Russia can achieve the huge project without foreign assistance. First of all, where is the capital to come from? Many Russian authors believe that foreign support cannot be looked for. They observe particularly that both England and France will themselves have need of their own capital, and that such capital as is attracted to Russia will prefer other investments to railroad securities. Besides, the conditions of the financial market after the war will be little favorable to loans on bonds, because of the inundation of all financial markets by government bonds.

MUST DEPEND ON HER OWN RESOURCES.

Russia therefore must depend upon her own resources. Opinion varies upon this point. Some propose to the government to issue an interior railroad loan, while others seek to utilize for this purpose the power of issue of the Government Bank, as was done for the military commands. But all count upon the improvement of the Russian financial market during the war.

Another problem is that of the provision of raw materials. It is a question not only of creating and equipping new metallurgic works, but also of increasing largely and rapidly the extraction of coal and iron ores. The existing works are insufficient to meet these demands and the authors of the project of railway extension lay stress on the creation of new centers of metallurgic industry. In the explicatory report they say that the solution of this problem must be sought in the reciprocal influence of new railroads and new centers of metallurgic industry created by these roads. The coal-bearing basin of Kouznetsk, superior in capacity to that of the Donetz; the iron ores of Teibek, similar to those of Krivoi-Rog; the coal of Abakansk, the coal and the iron and other ores of the Caucasus, of the southern Urals, etc., wait for exploitation upon the day when these regions shall be traversed by railroads.

INCREASED EFFICIENCY OF OLD LINES NECESSARY.

But while awaiting the formation of these new metallurgic centers, it is exigent at once to augment to the maximum the productivity of the old ones, and to favor the construction of new works. Certain authors, e. g. Prof. Migouline, propose to interest private contractors by well-proportioned long term contracts. Others, such as the Engineer Petchkof, advise the placing of immediate orders in America for the complete equipment of new works. Others, finally, demonstrate that new works cannot be created in Russia except under the conditions applied by the other allied powers to establishments employed in supplying military needs. These conditions involve either short term contracts at prices which provide for the amortization of at least half the cost of the necessary special equipment, or else long term contracts [which guarantee a reasonable useful life for that equipment]. In either case loans, advance payments and subsidies must be granted, payable either on account of the contract price, or as special credits.

Long terms accorded for the execution of contracts are recognized as being of great importance. But the creation of new works being necessitated by the construction of railroads, the question is raised, what will become of these works within five years after the projected system is completed? An epoch in the history of Russia is well known when the sudden reduction of railroad construction provoked a profound economic crisis. *PromicKlemonti Torgovlia* (*Industry and Commerce*), the organ of the great Russian industrials, in the issue of September 3-16, 1916, opines that private capital must exact, as a condition of its participation in railroad construction, that this should be distributed over a period of more than five years. Moreover, the commission which has elaborated the project of construction has emphasized the necessity of guaranteeing to industrial works long term contracts, of according them loans, advances, and subventions; of fixing the prices for the periods determined on, etc.

These demands, however, encounter many adversaries. Some of them find that Russia would be only too lucky to find the capital required for reconstructing the portion of the existing system comprised in the region of military action, for the repair and enlargement of its equipment of locomotives, and for the development of its junctions, which would demand at least $500,000,000. As for the construction of new railroads, even on a very modest plane, the effort required would be far too great. In these conditions it is impossible to undertake projects of too vast a scope, and still more to hope that Russia can execute them with her own resources. . . .

But both pessimists and optimists agree that Russia cannot get along without foreign assistance, and that without the co-operation of foreign capital, engineers and technicians, she will find it impossible to execute the new project whose success in great part depends on the future inflow of foreign capital.

*Le Génie Civil.

Tunneling Under a River

Difficulties Encountered in the Subway Work in New York

THE work of driving tunnels, especially when of a sub-aqueous character, is always accompanied by numerous surprises and unlooked-for incidents. The following account of some of the happenings in a pair of tunnels that have been driven under the East River, New York, in connection with the new subways now building, together with the methods used in overcoming the difficulties, is from an article by Clifford M. Holland, tunnel engineer, in the *Public Service Record*, published by the New York Public Service Commission:

One of the four pairs of tubes now being built under the East River, New York City, in connection with the contracts for the so-called "dual" system of rapid transit subways, passes under the East River at Old Slip, Manhattan. At this point considerable difficulty was experienced in holding the compressed air in the tunnel headings, due to conditions at the face of the excavation where the shield was partly in rock and partly in earth. This earth comprised very largely filled ground containing piling and old cribbing. At the water front, furthermore, the profile of the tunnels intersected the base of the South Street bulkhead wall, requiring the removal of its concrete foundation throughout the entire thickness of the wall.

The method of excavation was to drive a bottom heading of about 150 feet, into which a concrete cradle with steel rails imbedded was placed for the shield to slide on. The shield was shoved ahead on the imbedded rails 2 feet 2 inches at a time by the action of the shield jacks. Seventeen jacks were distributed around the periphery of the shield and their combined thrust, under a hydraulic pressure of 5,000 pounds per square inch, amounts to about 2,500 tons.

After each shove by the jacks one of the cast-iron rings with which the tunnel is lined was erected behind the shield inside the overlapping tail. Each ring is 2 feet 2 inches long and each consists of nine plates and a key, and is put into place by means of a hydraulic erector attached to the rear of the shield. The erector picks up each plate and pushes it into place, holding it there until it has been bolted to the last completed ring. The soft ground at the top was supported by breasting boards in order to prevent a run of material at the face of the excavation while the rock was being drilled and blasted with light charges. Progress under these conditions averaged about five feet every twenty-four hours.

In tunneling through soft ground under the river compressed air is used to drive the water out of the surrounding material and to prevent water from flowing into the tunnel, thus permitting the excavation to be done under dry conditions. The diameter of the heading on the present work is about eighteen feet, and as it is necessary to have the air pressure high enough to balance the water pressure at some point below the top of the shield there results an unbalanced pressure at the top of the tunnel due to the excess of air pressure over the water pressure at this point.

Blowouts in tunnel headings are caused by this unbalanced pressure, and in order to maintain a state of equilibrium it is necessary to have a considerable amount of material over the top of the shield as a dead weight to counterbalance this excess air pressure. Where the tunnels are under the river a thick blanket of clay is deposited in advance of the shield to serve as a cover through which the compressed air escaping from the face of the excavation cannot pass.

As long as the escape of the compressed air from the tunnel heading can be spread out around the edges of this covering blanket the danger of a blowout is largely eliminated, but if the escape of compressed air be all at one point, it is only a matter of time before it works a channel through the ground overhead and a blowout is almost certain to result.

It has been customary on this work to take daily soundings in advance of the tunnel shield in order to learn how serious the scouring of the river bed due to the escape of compressed air has been during the twenty-four hours previous, and if it appear that the thickness of the river bed has been materially diminished, additional blanket is deposited from scows in order to restore the cover to the proper depth. The thickness of the clay blanket required can be computed theoretically, but the uncertainty of the condition of the bottom of the river bed is such that no great reliance can be placed upon the computations, as a single hole not located by the sounding party is liable to result in a blowout. For this reason considerably more clay blanket is placed in advance of the tunnels than is theoretically required.

In determining the safety of conditions at the face of the excavation, the amount of cover over the top of the shield is only one of several factors which has to be reckoned with, as the escaping of the compressed air at the cutting edge and tail of the shield also depends largely upon the character of the material through which the tunnel is being driven. Oftentimes a "blow" on the river surface which is violent is not a serious matter owing to the porosity of the ground permitting a free escape of the compressed air even though there is sufficient material to withstand the unbalanced air pressure, while a small, insignificant blow in compact material may give a false sense of security. The best method of meeting this situation has been to profit by experience and never permit the cover overhead to become less than a fixed minimum.

Several delays varying from a few days to a month were caused by blowouts in the early stages of this work, two occurring while the tunnels were still under the city streets, and two where the tunnels were passing under the river bulkhead wall. Of these blowouts the most serious one occurred in the evening of December 1, 1915, preparatory to making a shove for a ring. The rock at the center of the shield directly under the breasting was shot with the men back at the tunnel bulkhead where they had retreated as was ecstomary. Immediately after the blast the pressure in the chamber dropped from 15½ pounds to 11 pounds, and the men went into the emergency lock in the top of the tunnel preparatory to going out, as such a drop in pressure indicated that a blowout had occurred at the face of the excavation. After a few minutes, however, the tunnel, which had fogged up due to the drop in pressure, cleared as the air pressure increased again to 15 pounds, and since this indicated that the inrush of material at the face of the excavation had probably choked the blow, the men returned into the heading.

Upon investigation it was found that there was a bad blow of compressed air at the cutting edge of the shield and every effort was made to stop the blow by feeding into it bags of sawdust, empty bags, hay, or anything else that could be thrown into the opening. After about five minutes a second blow occurred and the pressure again dropped to 11 pounds. The tunnel immediately fogged up as had occurred previously, and the center of the heading blew out. This produced such a strong rush of compressed air that several of the men were nearly drawn into the hole, for at the time there were six men in front of the shield attempting to stop the leakage of compressed air. One of these men was drawn into the opening up to his shoulders and was with difficulty pulled out by the other men who clung to the shield and rock. If it had not been for the rock in advance of the shield probably the whole six men would have been lost, but this gave them a firm support in addition to the shield against which they could brace themselves and resist the outgoing compressed air. All this took place in a very few seconds and the men barely escaped before the heading filled up.

The men left the tunnel by means of the emergency lock as the water kept gaining and it was evident that nothing could be done to regain the heading from within the tunnel. The heading was regained some time later by dumping additional cover in advance of the shield from scows loaded with clay, which filled the hole in the bottom of the river so that the tunnel would hold compressed air. After waiting several weeks the air pressure was raised and after mucking out the heading the work proceeded as before the blowout.

A similar blowout under the slip at the foot of Montague Street, on the Brooklyn side, where there was a full soft ground face, resulted in three men being blown out of the shield up through the bottom of the river, only one of whom came through alive.

To meet such an emergency as a blowout, there are two provisions made for the safety of the workmen. A safety screen, extending about one third the distance down from the top of the roof, is always kept in position to serve as a trap for the escaping compressed air. A seal is made as soon as the water reaches the bottom of the screen so all the compressed air cannot leave the tunnel. In addition there is an overhead runway suspended from the roof of the tunnel, extending from the shield under the safety screen back to the emergency lock located in the upper part of the concrete bulkhead. This lock is always kept open into the heading ready for any emergency.

In one of these blowouts a rather novel expedient was resorted to in order to reach the valve on the blow-pipe located near the shield. As the tunnels are on a down grade this valve was at the lowest point in the tunnel and, if it could be reached, by opening the valve it would be possible to blow all the water out of the tunnel heading without having to wait until additional pumps or new blow lines were installed.

One of the "sand hogs" who had had experience in diving volunteered to put on a diver's suit and go down into the heading under compressed air and open the valve. He made a successful trip down into the tunnel shield but reported that the river mud which had come in at the time of the blowout had entirely covered up the valve so that he could not reach it.

After each one of these blowouts the material in the tunnel heading was found to be a most curious mixture composed of river mud, paving blocks, brickbats, broken bottles, etc., and in one instance a live fish was found swimming around in the water.

The headings of the north tube of the Old Slip-Clark Street tunnel under the East River were "holed through" on November 28, providing an early Thanksgiving celebration for the "sand hogs" and other workers, the contractors and the commission's engineers.

There have averaged 500 men working in the four headings of the Old Slip-Clark Street tunnel. At one time the digging was being carried on under 37 pounds air pressure, which was the maximum reached. The maximum allowed is only 50 pounds to the square inch. When the pressure was at its highest an average of more than a thousand men were employed daily, owing to the short shifts permitted by law for caisson workers. At this period of the work the men were employed only one and one half hours at a stretch, entering the tunnels twice daily for an aggregate of three hours. The air pressure at the time of "holing through" had been reduced to 18 pounds and will be continuously reduced as the tunnel is caulked and made water tight, so that normal pressure will have been reached by the time the tunnel is ready for its concrete lining.

Maximum progress made on the tube just opened was 33 feet per day and the monthly maximum 343 feet. Average progress per day was 4.9 feet.

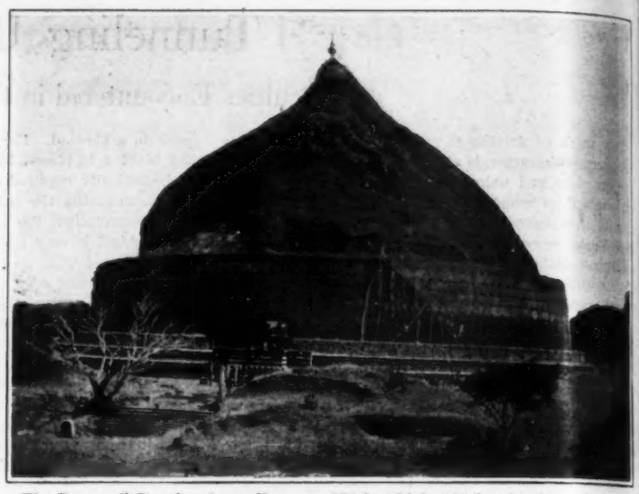
Shafts are located at Old Slip and Front Street, Manhattan, and on Furman Street at the foot of Clark Street, Brooklyn. The section has a total length of 5,900 feet, while the distance between the shafts is 3,800 feet. There is considerable shield driven tunnel work on the Brooklyn side. The contract price was $6,469,916.25.

The tunnel is 17 feet 6 inches in diameter and consists of two single track tubes. At greatest depth the bottom of the tunnel is 88 feet below the surface of the river.

Photomicrography for the Amateur

A VERY cheap and simple method of photomicrography without the use of a microscope can be devised by the following method: Take a piece of thin sheet brass, drill in it half-a-dozen holes with fine drills from ½ millimeter to 1½ millimeters. This should slide in front of a small 3-inch brass tube that can be attached to lens mount in such a way that while the brass tube can be pushed from or to the lens itself, the plate may be moved so as to bring any particular hole in front of the lens. If now a single drop of water is placed in each hole, a series of high-power objectives will be obtained that may be utilized for all general microphotographic purposes. The microscope slide should be mounted on a small stand, at the back of it a small tube in which is placed a small 8-volt incandescent lamp (so as to compel all light to pass through the slide). A drop of water which, received by camera lens, is focussed on screen and plate in usual manner. If the incandescent lamp bulb is coated with aniline violet emulsion so that violet light floods the slide lens and plate, a more perfect photo image will be obtained.—CHAS. MAYFIELD in the *English Mechanic*.

Thuparama Dagaba, at Anuradhapura said to be the oldest structure either in Ceylon or India



The Raunweli Dagaba, Anuradhapura; 270 feet high, 100 feet in circumference, showing elephant platform

The Ancient Capitals of Lanka

Wonderful Ruins in Ceylon That Antedate the Christian Era

By Carl Stearns Clancy

LONG forgotten, still popularly unknown, and until recently half covered by the corrosive accumulations of ages and hidden by dense jungle growths, the ancient capitals of Lanka, like the ruins of the Incas in Peru, the relics of the Mayas in Guatamala, and the remains of the Aztecs in Mexico, now afford a wonderland of interest for the archæological investigator and the tourist alike.

Scores of bell-shaped relic houses, ranging up to 400 feet in height and 1,500 feet in circumference, form the gigantic ruins that now make up the principal monuments to the magnificent civilization which thrived in Lanka (Ceylon) coevally with that of Rome, its unknown rival in luxury and architectural grandeur.

The cities were two in number, Anuradhapura, the ancient Sinhalese capital, from about 1000 B. C. to 500 A. D., and Polonarawa, the mediæval capital, which bloomed in the twelfth century.

ANURADHAPURA.

The grandeur of the mighty capital Anuradhapura with its uncounted millions of people can be guessed from the fact that the king's pleasure garden in the middle of the city was twenty square miles in extent. After his conversion to Buddhism, the reigning monarch of Lanka, King Tissa, donated these gardens for religious uses. The ruins of the temples and dagabas erected here as expressions of religious favor resulting from the sudden subsequent conversion of the whole Sinhalese nation to Buddhism in the third century B. C. and multiplied during the zealous popular worship of this creed in the centuries that followed, now form the majority of the monuments that not only bear record to the vastness and splendor of that age, but are now—two thousand years later—taking their places among the wonders of the world.

Starting from the center of the modern native town, numbering scarce 50,000 souls, to make a systematic tour of the ruins, one comes at first to the forest of monoliths remaining from the original 1,600 granite columns upon which rested the remarkable Brazen Palace. As this edifice, built by King Dutthagamini about 200 B. C. for his favorite community of Buddhist monks, is typical of all the palaces of that day, this brief quotation from an historical description of it written about 500 A. D. by Buddhist monks and since preserved in their monasteries, is interesting.

"This palace was 100 cubits square—length, breadth, and height all being the same. In it there were nine stories, each with 100 apartments. All these apartments were highly finished in silver; all the cornices thereof were embellished in gems. The flower ornaments thereof were also set with gems, and the tinkling festoons were of gold. In the center of the great hall of the palace was an ivory throne, on one side of which was a sun in gold, on another the moon in silver, on a third the stars in pearls," ending with "the building was covered with brazen tiles, hence its name, the Brazen Palace."

Needless to say there was not much left to a building of such intrinsic value after the series of invaders finished with it some fourteen centuries later.

One comes next to the Ruanweli Dagaba, the laying of whose foundation is described in the opening paragraph of this article. A dagaba, or relic house, was a huge bell-shaped mound of solid bricks built both as a monument for and to protect for all time a tiny sacred relic hidden in the center of its base. Time and frequent attacks of enemies have obliterated its original outline, but there is more than sufficient structure now remaining to verify the ancient account of its erection. When the pediment was complete and the relic chamber and receptacle constructed, the relic was entombed with a most elaborate ceremony participated in by the whole

Sacred Bo-Tree, transplanted here in 288 B. C.

populace. The relic was usually a footprint of Buddha or one of his bones, but in this case it was an exquisitely beautiful model of the "Sacred Bo-tree," made of precious metals.

The work of excavating and restoring this dagaba is going on slowly, but the race that could make these great shrines what they once were has vanished. A few pious pilgrims worship here, but from all visible evidences the Buddhist religion as well as its shrines seem here to be in a hopeless ruin.

MOST ANCIENT STRUCTURE IN INDIA OR CEYLON.

The "Thuparama" Dagaba near by, the present shrine of the Collar-bone Relic, is the only dagaba in good repair and actively used. Built by King Tissa in 306 B. C., it antedates any existing structure in Ceylon or India, and is still, though much smaller than the others, a remarkable monument to the skill of its builder. Originally 176 ornamental pillars of graded heights surrounded the Thuparama; of these but 31 now remain standing.

Continuing through the park-like grounds, pastured like an English estate with sheep and goats, and broken everywhere with half-buried ruins, one visits in succession the Abhayagiriya Dagaba, the greatest of all—405 feet high, with a dome 360 feet in diameter, and a base covering eight acres; the Jetawanarama Dagaba, not much smaller; the king's palace with its beautiful "Moonstone" entrance and decorative Guard Stones by the side; marble bath tanks equaling Rome's in luxury; elephant houses and great tanks where the state elephants were wont to take their morning plunge, and where their wild descendants still come to bathe; the curious Isurminia Temple dug out of a mammoth boulder on the edge of an artificial lake; and finally the sacred Bo-tree itself.

OLDEST TREE IN THE WORLD.

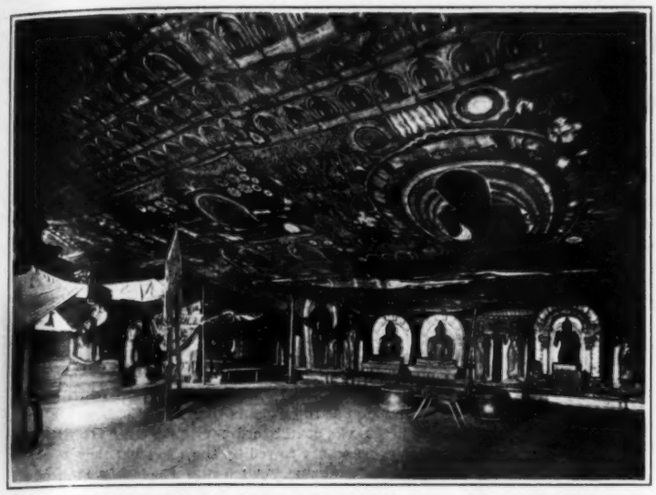
Transplanted here in 288 B. C., it is said to be the oldest cultivated tree in the world. Originally a branch of the fig tree under which Buddha had been accustomed to sit and meditate, it has flourished here for twenty-one centuries. Its venerale trunk is now nearly dead, but its offspring overshadow the once beautiful court of its inclosure. Still in daily use as a shrine, the tree is becoming more important as a side show for tourists.

POLONARAWA, THE MEDIAEVAL CAPITAL.

Long before one reaches the Rest-house at Polonarawa, on the banks of a charming artificial lake forty miles to the southeast of Anuradhapura, several of the remains of its old and splendid civilization appear by the roadside. The ruins of Polonarawa are found to be not inferior in boldness of conception and richness of design to any of the medieval world to which they were contemporary, lying just as they were smitten by the fury of the ancient Tamil conquerors, but gently buried by Nature and the hand of time. Although a British Archæological Commission is at work here, excavating and restoring the grandest of ruins, trees still take root on walls and roofs and rend them asunder; rank forest vegetation covers ornamental stone carvings and sculptured figures; and elephants yet come to drink at the marble bathing pools. Temples, monasteries, dagabas rivaling the Pyramids in magnitude, and bits of one of the three rectangular walls (four miles wide by thirty miles long) that inclosed the millioned city, hold one spell-bound for hours.

The most interesting of all relics to be discovered here, however, was the temple called the "Gal Wihare," and the three giant figures at its entrance. Still part of the ledge from which they were hewn, here sits a figure of Buddha 15 feet high; next comes an erect statue 23 feet tall—it is "Ananda," Buddha's favorite disciple; then follows a recumbent staute of Buddha himself—it is only 46 feet long; Buddha was supposed to have been that size when he finally and permanently died. So clever was the work of the sculptor that the mammoth head sinks into the embroidered bolster very naturally and the graceful folds of his robe suggest nothing but calm repose. That modern devotees make pilgrimages here occasionally is shown by the remains of their flower offerings and incense candles on the crude altar. And why should a visitor make merry? As an East Indian proverb says: "Your gods and my gods—do you or I know which is the stronger?"

The distinct feature of the Polunarawan buildings is the Hindoo character of their exterior, and this curiosity has not been explained. Shown clearly, however, is the fact that this mediæval capital abounded in then-



Ancient frescoes and images in the rock temple of Dambulla, dating back to 343 B. C.

Moonstone steps in the ruined city of Anuradhapura. At entrance to the Queen's palace

ters, bathing halls, gardens, fountains, public buildings that shone with roofs, doors, and windows of gold; and palaces whose splendor has never been excelled; and that it was even richer than Anuradhapura is apparent. To-day troops of huge gray monkeys, almost man size, with black faces and long black tails, leap to and fro among the trees, and excepting for the comfortable Rest-house, the jungle reigns supreme.

THE ROCK OF SIGIRI.

About the year 475 A. D. a fiendish Sinhalese prince named Kasyapa, who had killed his father to obtain the throne, and rendered himself more unpopular by other crimes, dared no longer to live openly at Anuradhapura —then the capital—for fear of his brother's revenge. He therefore retired to the rock of Sigiri, in the center of a vast jungle, and strongly fortified it. The perpendicular sides of the rock, over 400 feet high, made climbing impossible, but the clever Kasyapa constructed a balconied stiarway gradually winding around it from base to summit. Upon the four acres of the top he built a splendid palace and administration buildings, and lived in great luxury until his Buddhist conscience began to trouble him. Later his brother's overwhelming army, recruited in India, cut his own to pieces and frightened him into suicide; whereupon his brother wrecked the fortress and returned to the north.

Several long flights of stone steps remain to lead up the terraced slopes to the foot of the cliffs, where the rock foundations of temples and houses, and huge bath tanks cut into the top of great boulders are clearly to be seen. From here one mounts the restored stairways of stone and iron to the foot of the original inclined walk, part of which yet remains. Now a wonderful view opens out over the lake-like mist settled upon the jungle for miles around, with the craggy mountains protruding like islands in the distance.

Forty-five feet above the center of the stairway is a pocket or shallow cave in the rock, which formed the ancient Guard Room or "look-out" for the fortress. The remarkable frescoes that still adorn its rocky wall are well worth the shaky climb up the wire and bamboo ladder that hangs perilously on stays driven into the face of the cliff. Having crawled slowly up the ladder, swinging clear out beyond the jutting rock over a sheer 300-foot drop and tested his nerves to the limit, one finds several frescoes 1,430 years old—ladies with complexions bright and fresh in spite of their exposure to the monsoons of nearly fifteen centuries.

The 9-foot wall that was built on the outside edge of the ascending gallery has an inner surface as polished and almost as hard as marble, yet it was only coated with chunan, a kind of cement that has remained so well preserved that graft seems to have been unknown in ancient days. This overhanging balcony leads on and up around to the terraced north side of the rock where half the foundations of ancient buildings still remain, the absent half having been supported by more temporary sub-structure. Then a long iron stairway, recently built by the Archæological Commissioners mounts to a wide ledge, once the site of a temple, where the archæological coolies will soon be at work.

Now the royal grand staircase, partly restored, leads up in terraced flights between two colossal lion's paws and forelegs, masoned of huge bricks and mortar. At the lion's chest the original steps end, and zig-zaging iron stairs lead directly to a second ledge. From here the footholds are the original foundation drillings for the great buildings of the top, the danger of slipping being guarded by an iron hand rail.

Arriving breathless at the top, one finds four acres of what at first glance seem the half-sister to a brick yard. Exploration, however, reveals four great bath tanks cut out of the solid rock, now full of rain water; a large couch—the king's—carved out of the rock of which it

The Jetwanarama Temple and the Thuparama Dagaba at Polonarawa

is still a part, a flight of stairs in quartz, court-yards, passages, and many other evidences of royal dominion. The view from the top is magnificent, and in itself enough to attract the crowds of people from all over the world who are expected to visit here as soon as the wonders of romantic Sigiri and the buried cities of Ceylon become more generally known.

How to Recognize Good Table Poultry

THE following statement of the methods by which good table poultry can be recognized by the purchaser is made in bulletin 467 of the Department of Agriculture.

"In a freshly killed bird the feet feel moist, soft, and limber, and if it was dressed with the head on, the eyes look bright and full. As it becomes stale the eyes shrink and the feet dry and harden; when too stale, *i. e.*, when decomposition is well under way, the body turns dark and greenish or becomes slimy. The flesh should be neither flabby nor stiff, but should give evenly and gently when pressed by the finger. It is very difficult to distinguish between good cold-storage and freshly killed poultry.

"One of the commonest ways of testing the age of dressed poultry is to take the end of the breastbone farthest from the head between thumb and finger and attempt to bend it to one side. In a very young bird, say a 'broiler' chicken or a green goose, it will be easily bent, like the cartilage in the human ear; in a bird a year or so old it will be brittle, and in an old bird, tough, and hard to bend or break. Unfortunately there are sometimes tricky dealers who break the end of the breastbone before showing the bird, and thus render the test worthless. If the feet are left on the carcass, they furnish a mark of age. In a young bird they are soft and smooth, becoming hard and rough as the bird grows older. The claws are short and sharp in a young bird, growing longer and blunter with age and use. Spurs generally occur on male chickens. On male broilers and tender roasting chickens they are small; on older, higher-flavored ones they are prominent but flexible; on cocks they are long and attached to the bones of the legs; on capons they seldom develop until the second year of age.

"Turkeys up to a year old are said to have black feet, which grow pink up to three years old and then gradually turn gray and dull.

"The age of pigeons can sometimes be told by the color of the breast, which becomes more and more purplish as the bird grows older. Red feet are also said to be a sign of age in a pigeon.

"In ducks and geese the flexibility of the windpipe is a mark of youth. It can be easily squeezed and moved when the bird is young, but later grows rigid and fixed. If the tips of the quills at the end of the wing are sharply pointed the bird is probably young; the blunter they are, the older the bird.

CAPONS

"When caponizing has been properly done, the head is small for the size of the body, the comb and wattles are pale and withered, the body plumper, rounder, and larger than in an ordinary fowl, and the spur abortive. If the operation was incomplete, the head will be like that of an ordinary bird and the body less rounded. Such birds, known technically as 'slip capons,' are much inferior to true capons."

Cable Telegraphy

A NEW invention, devised by Mr. J. B. Dixon, has been in practical operation on certain of the Atlantic cables, and is reported to have given remarkable results, the speed of operation in the commercial handling of cable messages have been increased upwards of 125 per cent, while in tests far greater speeds have been attained. The gain in speed is due to the use of selenium cells to amplify the signals received, and to the use of means for obtaining, from one or more sources of illumination, a very large number of light beams, concentrated coincidently upon selenium cells, and deflected by a line galvanometer across the surface of the cells, the effect being that a very intense illumination of the cells is obtained. It is found that the practicable speed of operation increases as the intensity of illumination increases. The selenium cells operate a siphon recorder or a relay. There being no physical connection between the recorder or relay and the line galvanometer, the inertia and frictional losses present in the older magnifying and recording apparatus are largely eliminated, the more so as in the new system the amplitude of vibration of the galvanometer coil is, in general, much less than in the case of the older apparatus. It is stated that Mr. Dixon employed 45 separate light beams, all derived from one 400 candle-power tungsten lamp, and all concentrated on a thin galvanometer mirror 5 inches long and 3/16 inch wide. These light beams were reflected from the galvanometer mirror, in ome case, a distance of 7 feet 6 inches, and were then re-reflected a further distance of 7 feet 6 inches to the selenium cells, the light beams being concentrated coincidently upon the cells. With this apparatus, working over one of the trans-Atlantic cables, the normal rate of operation of which is less than two hundred letters per minute, a speed of 450 letters per minute and higher was obtained in the regular commercial handling of business, and still higher speeds have been obtained on tests, with signals fully readable as to size and character.—*Journal of the Royal Society of Arts.*

On the Correct Adjustment of Chemical Weights*

To Secure Accuracy In Comparisons of Substances Under Investigation

By William Crookes, F.R.S.

A SET of grain or gramme weights, as ordinarily supplied by even the best instrument-maker, is never absolutely exact. However carefully they may be adjusted, the pieces of metal which respectively represent 1,000 grains, 100 grains, 10 grains, etc., are only more or less approximations to the true weights. It is impossible for any one to adjust them with absolute accuracy. Indeed, the best makers readily acknowledge this, and are careful not to guarantee the correctness of their weights beyond certain limits.

In most chemical analyses the error arising from inaccuracies in the weights used is so small in comparison to errors of manipulation, or to imperfections inherent in the chemical processes adopted, that it may generally be disregarded; but when the chemist has for his object the determination of an atomic weight, or is engaged in other researches demanding the highest refinement of accuracy which chemistry and physics can supply, then he is bound to neglect no correction which will increase the precision of the results.

That chemists, whose well-trained reasoning power allow them to take for granted nothing which is capable of experimental verification, and who insist upon the utmost attainable precision in their balances, should, as a rule entirely neglect the probable errors which the inaccuracies of their weights may introduce, is somewhat surprising.

For the last four years I have been engaged in an investigation, the results of which will shortly appear in this journal. In carrying out this investigation, it has been my endeavor to avail myself of every possible refinement to insure accuracy. In order to eliminate the errors introduced by varying atmospheric pressure, the weighings and many of the chemical reactions have been performed in a vacuum. It is not my intention in the present paper to discuss the subject of weighing *in vacuo;* but as many friends from time to time, while witnessing my methods of weighing, have expressed a wish to have placed on record, for future reference, the plan adopted for adjusting weights, and as, moreover, I am not cognizant of the existence of any published directions, except those cited below, I am induced to place a short notice of my method of procedure before the readers of the *Chemical News.* Let me commence by disclaiming any originality in the process. Prof. W. H. Miller, of Cambridge, in his classical researches on the determination of the standard pound (*Philosophical Transactions* for 1856, pp. 811, 827, 937), has given full directions for attaining a similar object. These, however, will not exactly apply to the systems of weights used by chemists; for of the three cases described by him, the former two concern a peculiar system of weights, and in the third, two sets of weights, one for the Exchequer, the other for the Royal Mint, were compared at the same time. To this paper, as well as to the learned author himself, I am indebted for an immense store of valuable information on the subject of weights and weighings.

It may make this description clearer if I give exactly as they were performed the details of the adjustment of a set of brass grain-weights with which some of my earliest researches were carried out. These weights, new, and made by one of the best English firms, Messrs. Ladd and Oertling, may, therefore, be considered as accurate a set as any in ordinary use.

For nearly every process in which weights are used in chemistry, the object is not to ascertain the *absolute* weight of a substance in terms of a grain or gramme, but to determine its *relative* weight, in comparison with that which it possessed at some other time before it was submitted to certain analytical or synthetical operations. If the weighings are performed with the same weights, it does not at all matter whether the weights are absolutely of the value which they profess to be, but it is very important that they should bear a known proportion to each other. The highest weight (1,000 grains) in the set should be taken as the standard. It is immaterial whether or not this is accurately 1,000 standard grains,[1] but, *calling it* 1,000 grains, the value of the other weights should be known in terms of this weight with the greatest attainable accuracy.

The first operation consists in taking the specific gravities of each brass weight. The density of the larger weights must be ascertained at least to the second place of decimals, and that of the smaller ones to the first place. The specific gravity of each weight should be separately determined; for brass weights, even of the same set, differ greatly in density among themselves. A variation of not more than 0.05 in the specific gravity of the 1,000 grain weight, will cause a difference in the amount of air it displaces of about 0.001 grain.

The balance being brought into equilibrium, the 1,000 grain weight is placed in the left pan, and in the right are placed the 600, the 300, and the 100 grain weights. It is now found that, to bring the balance back to equilibrium, a slight additional weight has to be placed on the right side, to supplement the three weights already in that pan. This is noted. The weights are then removed to the opposite pans, the 1,000 grains being on the right, and the three smaller weights on the left. It is now found that a small weight has to be subtracted from the side carrying the three weights, in order to produce equilibrium. The weights are removed and interchanged in this manner ten times, so as to eliminate, as far as possible, the errors arising from observation, or the unequal expansion by heat of the arms of the balance; and by applying the method of least squares to the results obtained, we at last arrive at the equation:

$$(1{,}000)^2 = (600) + (300) + (100) + 0.00106 \text{ grains} \ldots a$$

In a similar manner the values of the (600), the (300), and the (100) weights are ascertained in terms of the other weights, thus:

$$(600) = (300) + (200) + (100) - 0.00485 \text{ grains} \ldots\ldots b$$
$$(300) = (200) + (100) - 0.00574 \text{ grains} \ldots\ldots c$$
$$(200) = (100) + (60) + (30) + (10) + 0.00057 \text{ grs.} \ldots d$$
$$(100) = (60) + (30) + (10) + 0.00105 \text{ grains} \ldots\ldots e$$

We now have data for ascertaining the absolute values of the larger weights in terms of the (1,000) weight, taken as standard. Adding a and b together gives:

$$(1{,}000) = 2(300) + (200) + 2(100) + 0{,}00591 \text{ grains} \ldots f$$

Multiplying c by 2 gives:

$$2(300) = 2(200) + 2(100) - 0.01148 \text{ grains} \ldots\ldots g$$

Subtracting e from d gives:

$$(200) = 2(100) - 0.00048 \text{ grains} \ldots\ldots h$$

Now, by adding f, g, and three times h, we get:

$$(1{,}000) = 10(100) - 0.00701$$

$$\therefore \frac{(1000)}{10} = (100) - 0{\cdot}000701$$

and

$$\therefore (100) = 100.000701 \text{ grains.}$$

Substituting this value for the (100) weight, we get from equation e:

$$100.000701 \text{ grains} = (60) + (30) + (10) + 0.00105 \text{ grains,}$$

or

$$(60) + (30) + (10) = 99.999651 \text{ grains.}$$

From equation d we get:

$$(200) = 100.000701 + 99.999651 + 0.00057 \text{ grains,}$$

or

$$(200) = 200.000922 \text{ grains.}$$

From equation c we get:

$$(300) = 200.000922 + 100.000701 - 0.00574 \text{ grains,}$$

or

$$(300) = 299.995882 \text{ grains.}$$

From equation b we get:

$$(600) = 299.995882 + 200.000922 + 100.000701 + 0.004485 \text{ grains,}$$

or

$$(600) = 600.002355 \text{ grains.}$$

The next step is to ascertain the value of the smaller weights. It is now necessary to obtain a second 10 grain weight. This I will call (x); and I will assume that:

$$(60) + (30) + (10) = 100 \text{ grains} \pm i.$$

(In this case, from equation e, the value of i is seen to be −0.00035 grain.)

By an exactly similar mode of intercomparison, the following equations are now obtained:

$$(60) = (30) + (20) + (10) + 0.00270 \ldots\ldots k$$
$$(30) = (20) + (10) - 0.00037 \ldots\ldots l$$
$$(20) = (10) + (x) - 0.00103 \ldots\ldots m$$
$$(10) = (x) \pm 0.00000 \ldots\ldots n$$

Then, by repeating the above process of adding, multiplying, or subtracting, we finally get the true values of these smaller weights. The same process is then to be extended to the whole of the other weights.

The value of the weights thus given is, however, their weight in *air* of the ordinary pressure. It therefore becomes necessary to reduce them to what they would be worth in a vacuum. All bodies displace a bulk of air equal to their own volume, and the weight of this air is therefore greater as their specific gravity diminishes. In delicate investigations this loss of weight in air is important; for 7,000 grains of brass displace, roughly, one grain of air.

By proceeding according to known rules, the value of the weights *in vacuo* is finally ascertained, and the results are embodied in the following table.[2] It is assumed that the (1,000) weight really weighs 1,000 grains in air:

Names of the weights.	Value in air in terms of the (1000) grain weight. grains.	Value *in vacuo* in terms of the (1000) gr. weight. grains.	Weight of air displaced by each. grains.	Volume of weights in grs. of water of maximum density.
(1000) .	1000.0000	1000.1462	0.1462	119.193
(600) .	600.0023	600.0904	0.0881	71.812
(300) .	299.9959	300.0401	0.0442	36.035
(200) .	200.0009	200.0303	0.0294	23.930
(100) .	100.0007	100.0153	0.0146	11.868
(60) .	60.0007	60.0091	0.0084	7.140
(30) .	29.9988	30.0040	0.0052	3.538
(20) .	19.9991	20.0030	0.0039	2.358
(10) .	10.0001	10.0015	0.0014	1.166

Because these corrections are individually small, it is not right to assume that they may be neglected. The weights submitted to the above adjustment were exceptionally good, and must not be considered as fair representatives of those usually employed in analysis. I have met with weights in which the deviations from their true values were one hundred times as great as in the foregoing instance; and as no one can be certain that some of his weights are not faulty, it is best to ascertain their relative values once for all; for as the deviations are sometimes in excess and sometimes in defect, they are liable to accumulate in one or the other direction, and thus produce errors in weighing of considerable magnitude.

Having ascertained their true value, the weights ought to be carefully preserved. No attempt should be made to get them more accurately adjusted by adding to or removing portions of the metal, and they should not be picked up with metal forceps, as they suffer thus by wear and become lighter.

When possible the chemist should always use platinum weights. After adjusting the weights in question, I found that, owing to the accumulation of tarnish on their surface, there was danger of their becoming faulty. I accordingly procured from Messrs. Johnson and Matthey another set, the separate weights of which were turned out of bars of well-fused platinum. After having bestowed several months' labor upon them, I have now the satisfaction of knowing that they are as near perfection as could reasonably be expected. They have been in use for nearly three years, both in air of the ordinary pressure and *in vacuo*, and comparisons made a few days ago show that their values remain absolutely unaltered.

Washing Flannels

"WHAT the laundry usually has to contend against in washing new flannels or blankets is not the sulphur, but the dressing which is employed to give added weight and substance to the wool, and to make the fabric appear heavier and better than it really is in the eyes of the unsuspecting purchaser. This is a practice which should be absolutely prohibited by law, as it is nothing more or less than a deliberate fraud upon the public."

The Chemical News, November 10, 1916. Reprinted from the *Chemical News*, vol. xv., No. 385, April 19, 1867, at the request of many readers.

[1] This must be understood as referring only to ordinary chemical research in synthesis or analysis. In many physical investigations it is of great importance that the 1,000 grain weight should really represent 1,000 normal grains, or that its deviation from that value should be accurately determined. But I confess I do not know where a standard weight suitable for such a comparison is to be met with.

[2] For distinctness, when speaking of the pieces of brass which are stamped 1,000, 600, 100 grains, etc., I represent them by their nominal value enclosed within brackets.

[3] To avoid extending the table to unnecessary limits, I omit the weight below 10 grains.

How Waste Paper Is Used In Paper Mills

Paper Shortage Would be Reduced and Householders Make Pin Money by Paper Saving

ACCORDING to investigations begun by a committee of the American Chemical Society, an advance report of which has just been issued, storekeepers and householders might get better returns from sales of waste paper to itinerant collectors if they would make some attempt at sorting out the material before it is offered for disposal. The collectors of mixed waste papers will readily pay a higher price for the material when it is offered to them in separate flat bundles carefully divided into the various sorts, such as magazines, account books, ledgers, brown wrapping, newspapers, and common mixed paper trash, including paper boxes. The price paid by collectors for the hodge-podge bundle of waste papers made ready for them by housewives and servants is 40 cents per 100 pounds. A bundle of this kind may contain anything from scraps of letter paper to leaves of ledger paper, magazines, pamphlets, books and newspapers, worth to the dealer anywhere from $4 to 60 cents per 100 pounds delivered at the mill. For ordinary grades of magazine paper the mills now pay from $2 to $2.50 per 100 pounds, but storekeepers and housewives seldom realize more than 60 cents from sales of magazines and accumulations, and when monthly magazines like *McClure's*, the *Delineator* and the *Ladies' Home Journal* are indiscriminately lumped with newspapers and telephone books, for example, 40 cents is the highest price that can be obtained for them from collectors.

As noted in a recent bulletin of the American Newspaper Publishers' Association, less than half the paper used in the city finds its way back to paper stock companies for conversion into new paper. At this time particularly, when the country confronts a serious condition in its paper supply, it is worth money to them, and in course of a year the waste paper of any home can be turned into a considerable item of pin money. Newspapers, magazines, wrapping paper—discarded paper of any kind that is fit for making over—will be bought by the paper stock houses. Institutions and charitable organizations find waste paper an important source of income in their philanthropic enterprises. They make regular collections of it in the residence districts, and many persons who are deeply sympathetic with the humanitarian work of such societies save all paper and give it to the collectors. If all the waste paper fit for reconversion were turned back to paper houses it would tend to reduce the paper shortage materially.

Old magazines form acceptable material for conversion into what is called book paper, the stock on which many trade periodicals and the cheaper illustrated weeklies are printed, besides the catalogues issued by mail order houses. The body of magazine paper is formed out of cooked woodpulp, consisting of nearly pure cellulose, a substance that will stand boiling in solutions of caustic lye for the removal of printer's ink, and subsequent bleaching, without undergoing further discoloration or material damage to the fibers. In the case of old newspapers it is different. These cannot be washed in hot alkaline solutions and repulped to form a new sheet of paper at a profit because the paper is composed of raw, uncooked wood having only a small proportion of added cellulose to hold it together. Strong alkaline solvents of printer's ink have a discoloring effect on newsprint paper, and bleaching agents have a detrimental action on the fiber, so that, after treatment, a pulp is obtained of grayish color that falls far below the weight of the original sheet, and is only suitable for conversion into cardboard for use in the manufacture of paper boxes and shipping containers, or for the manufacture of inferior grades of wrapping paper and wall paper.

A good technical account of the process employed in the regeneration of waste paper is given by a member of the Press and Publicity Committee of the American Chemical Society in a paper contributed to a recent issue of the SCIENTIFIC AMERICAN. The author points out that processes innumerable have been devised for reclaiming waste paper by the application of methods for the removal of printer's ink, but that the ideal system of treating all grades of printed paper so as to produce a clean white pulp capable of conversion into paper of the same quality as the original seems to be as far off as it was when experiments were first undertaken a century ago.

Old magazines and other waste papers, which have a body of rags or cooked wood pulp, are now in good demand and collectors will pay high prices for picked material, a large tonnage of book paper being produced from this source annually in many paper mills throughout the country.

The regeneration of the waste paper is accomplished in a simple manner. After the material has been examined and tested for the exclusion of paper made of mechanically ground wood pulp, the mass is torn into shreds by machinery and fanned to remove dust. It is then loaded into large boilers capable of holding several tons of material. The boiler is then filled with a weak solution of soda ash, and steamed under a moderate pressure. As the object is to effect a mere surface loosening of the printer's ink in order to facilitate the subsequent washing process, a weak lye is used and the heat applied is kept well under the boiling point; too much soda and the application of a high degree of heat would disintegrate the fibers and loosen up the paper more than would be desirable. The treatment of papers printed chiefly with soluble inks and dyes does not offer much difficulty. In many cases the mere soaking in water is sufficient to remove the ink and to give a pulp of a fairly white character. With paper containing ordinary printer's ink the case is different. This ink consists of a pigment, usually carbon black or animal black, combined with a vehicle in the shape of a rosin varnish with a mineral or a vegetable oil as solvent. The more expensive inks use boiled linseed oil. In the case of varnishes made with vegetable oil vehicles like linseed, which saponify fairly well on treatment with a solution of soda, the oily constituents of the ink are converted into a soluble soap and the ink is consequently more easily detached from the surface of the paper. If it were then possible to treat the paper superficially and carry away the dissolved and the loosened constituents, there might be some chance of more or less complete removal of the ink. But the minute particles of carbon which constitute the pigment are not in any sense attacked, being merely freed from their combination with the varnish, and any attempts to remove this pigment constituent must rely entirely upon mechanical means. Resort is usually had to some form of sieve, such as an ordinary drum washer revolving in the vessel containing the old paper suitably pulped, or by passing the pulped paper treated with the soda lye over flat sieves or screens.

During recent years the attention of experimenters has been directed to mechanical means of brushing the adherent ink from the paper after it has been loosened by treatment with an alkaline solution. This object has been attained to a greater or less extent by two inventors of machinery for reclaiming old paper, one in Germany and the other in the United States. Under the German invention the printed or written old paper is thrown, in measured quantities, into a cylindrical screen. This revolves in a vat containing a weak solution of soda ash, bisulphite of soda and another alkali that exerts a bleaching as well as a solvent action. The slightly heated alkaline liquor permeates the paper and saponifies the printer's ink, which is dissolved away. By the revolving motion of the cylindrical screen or drum the paper is gradually reduced to a coarse pulp, some of the larger pieces of paper often resisting the treatment. After ten or fifteen minutes of churning the charge of partly pulped material is transferred to another machine, where the adhering lye is separated from it to be used over again in the first soaking drum. The pulpy mass is then treated with fresh lye and washed with water in a disintegrating machine where the finest particles of color and dirt are removed from the fibers. When this process is completed and the fiber pulp is separated completely from the dark fluid that contains the mineral ingredients (clay, etc.) and the saponified printing ink, the mass of fibers is moved slowly forward on a long, narrow, close-meshed traveling screen of wire. Here the superfluous water is abstracted. On its way the mass is sprayed vigorously several times by water from sprinkler pipes, being thereby stirred up, washed out and freed from the last traces of dirt and lye. The greater portion of the washing water runs off during the washing process, the remainder being removed by a pressing roll arranged at the end of the traveling sieve or screen. From the rolls the now finished pulp is removed by a scraper to be returned to the stuff vat of the paper machine, either directly, or after preliminary mixing with clay, size and other substances required in the production of different papers. One of the advantages claimed for this invention is an economy in material, as none of the long cellulose fibers are lost in the washing, conducted as it is over a fine meshed screen.

The American invention, known as the Winestock process, is distinguished by several novel features, most important of which is the maintenance of a rapid and steady circulation until all the stock is defibered. Circulation is maintained by a pair of propellers situated at the bottom of a tank equipped with a draft tube. These propellers are driven at a high rate of speed, the intent being to have the blades strike the floating particles of paper with such quickness that, embedded as they are in water or a weak alkaline solution, they are unable to take up bodily the rapid motion of the propeller blades, and therefore are pulled out, defibering the paper without materially shortening the fiber, while at the same time loosening the ink. The propeller performs the secondary function of producing rapid circulation of the material without the necessity of using a pump. The blades are overdriven or cavitating screw propellers similar to those used in marine work. The ink removal is effected by a combination of the loosening action due to defibering and the scrubbing action of the blades in the presence of a milk alkaline detergent. The detergent and defibering action of the Winestock process is said to be so efficient that the recovered stock requires no bleaching. This is an advantage of great weight, particularly since small amounts of ground wood are liable to creep in despite careful sorting, and render the color unsatisfactory if bleaching is depended upon.

Although it is possible, without the addition of any stock, to make a good quality of book paper from pulp recovered by the Winestock process, it has been found desirable to add a small percentage of fresh sulphite pulp to the material in the beating engine. Unusually good results have been obtained with the Winestock machine in the cleansing and defibering of waste newsprint paper, though for reasons already stated it is economically impracticable to use pulped newspapers for the manufacture of new paper. After treatment and washing in water, the recovered pulp is found to be of a yellow, natural wood color, which can be toned to the tint of ordinary newsprint paper by means of blue and red dye and, to some extent, by the use of clay as a filler. The recovered fiber from mixed papers shows good color, strength and appearance and the material might be worked back into papers nearly identical with those from which the fiber was recovered, but it would hardly be profitable to do so considering the present price of ground wood pulp.

Although papers produced wholly or largely from previously manufactured material may be made to resemble in appearance the original sheet, they never show up so well as first-hand stock. Such papers are more opaque, are flabbier to the touch and weaker in tearing strength than papers formed of new material. But in these days of paper scarcity, the supply of book paper manufactured out of old material is inadequate to the demand even at three times the price paid prior to the outbreak of war in Europe.

Colored Photography

IN 1874 St. Florent described a simple method in the "Bull. Soc. Franc." which has never been properly developed, and, owing to incessant production of new processes, has now almost completely dropped from practical investigators' memories; and yet it is one that promises very great possibilities. I will not take up space with description of its original detail and data, but only with those facts that have resulted from personal experiments—to be honest, all based on the original process of St. Florent, If any collodion chloride paper is exposed to magnesium light for, say, 70 seconds (till almost black), immersed in a bath of methylated spirit, 4 ounces, glycerine ¼ spoonful, 1 per cent., tincture iodine ¼ spoonful, and about 10 to 15 drops of .880 ammonia, let paper dry in warm place free from dust. If this is exposed under any colored transparency for about two hours in not too bright sunshine, fix in ordinary 10 per cent hypo. solution, wash and dry as usual, colors disappear in fixing bath, but reappear when dry paper is slightly warmed. Great possibilities are open for experiments working on these lines.—CHAS. MAYFIELD, in the *English Mechanic*.

The Earth's Magnetism*

The Discoveries of Halley's Expedition and Recent Investigations

By L. A. Bauer

Director, Department of Terrestrial Magnetism, Carnegie Institution of Washington

AFTER Halley had made two attempts to establish a working theory respecting the distribution of terrestrial magnetism and the cause of its striking change with the lapse of years—the so-called secular variation—he must have reached the conclusion that the elusive problem of the earth's magnetism would be more profitably advanced by additional facts than by further speculation. That, paraphrasing Seneca, to avoid making a false calculation of matters, it were better to advise with nature rather than with opinion. Accordingly we find him setting out in October, 1698, in command of a sailing ship, the "Paramour, and cruising in her under orders from the British Government, back and forth, north and south, in the Atlantic Ocean for two years, observing almost daily, sometimes several times in a day, the angle which the compass needle makes with the true north and south line—the angle known to the man of science as the magnetic declination, to the mariner and surveyor as the "variation of the compass."

This is memorable as being the first scientific expedition sent out by any country with the specific object of improving existing knowledge regarding certain facts of the earth's magnetism. Not until somewhat over two centuries later did it occur again, that a sailing ship traversed the oceans with the chief purpose of making magnetic observations.[1] In July, 1905, there sailed from the port of San Francisco, Cal., a chartered sailing yacht, the "Galilee," sent under the auspices of the Cargenie Institution of Washington, on the sole mission to determine the magnetic elements at sea, for the benefit of both the mariner and the man of science, as was also the purpose of Halley's voyages. Four years later, in 1909, a specially built nonmagnetic vessel, likewise under the auspices of the Carnegie Institution of Washington, left New York for St. Johns, Newfoundland, and thence proceeded to Falmouth, along practically the same track followed by Halley's ship. Since then this vessel, the "Carnegie," has circumnavigated the globe and has repeatedly intersected the course of the "Paramour" in the Atlantic Ocean.

In view of the historic interest thus attaching to Halley's magnetic expedition, it will be well worth our while to use this as our starting point or center, the fifth point in the Chinese compass. The instructions given Halley, as far as they pertained to his observatorial work, were as follows:

"Wherens his Majesty has been pleased to lend his pink the "Paramour" for your proceeding with her on an expedition to improve the knowledge of the Longitude and variations of the Compasse, which shipp is now completely Man'd, Stored, and Victualled, at his Majesty's charge for the said Expedition; you are therefore hereby required and directed to proceed with her according to the following instructions:

"You are to make the best of your way to the southward of the Equator, and there to observe on the East Coast of South America, and the West Coast of Africa, the variations of the Compasse with all the accuracy you can, as also the true situation both of Longitude and Latitude of the Ports where you arrive.

"You are likewise to make the like observations at as many of the islands in the seas between the aforesaid Coasts as you can (without too much deviation) bring into your Course; and, if the season of the year permit, you are to stand soe farr into the South till you discover the Coast of the Terra Incognita, supposed to lie between Mongolan's Straits and the Cape of Good Hope, which Coast you carefully lay down in its true position. In your return home you are to visit the English West India Plantations or as many of them as conveniently you may, and in them make such observations as may contribute to lay them down truely in their Geographicall Situation. And in all the Course of your voyage you must be careful to omit no opportunity of noting the variation of the Compasse, of which you are to keep a Register in your Journal."

Halley's Atlantic Chart of the lines of equal magnetic declination as based on his observations made during the cruise of the "Paramour Pink," 1698-1700

[The dotted lines show the tracks followed by Halley's vessel]

Curiously enough, Halley, though a prominent member of the Royal Society, never contributed a paper to it, nor did he publish anything elsewhere on these voyages of his, his observations, or resulting conclusions. Not until 1775 were Halley's journal and observations published, and then by Alexander Dalrymple in his "Collection of Voyages chiefly in the Southern Atlantick Ocean," from the manuscript in the possession of the Board of Longitude at London. Halley appears to have contented himself with laying down the results of his work on a chart entitled, "A new and correct Sea Chart of the Whole World, showing the Variations of the Compass as they are found in the year 1700." This chart is often briefly referred to under the title, "Tabula Nautica." The first edition, published probably in 1701, covered only the ocean—the Atlantic—traversed by Halley himself; for the later edition, as the chart was now to cover the greater part of the globe, he had to collect and utilize observations made by others. No printed reference to the early edition, either by Halley or by anyone else, prior to my discovery of a copy in the British Museum in 1895 has thus far come to light. Yet this particular chart, termed by me the "Atlantic Chart," to distinguish it from the later one—the "World Chart"—is especially interesting, as it contains the routes followed by the "Paramour." Airy, when he reproduced Halley's "World Chart" in the Greenwich observations of 1869, was seemingly not aware of the "Atlantic Chart."[2] (See Figure 1.)

The only description of Halley's chart by himself, thus far found, is that either attached to certain editions of the chart or contained on an accompanying leaflet. This, however, is very brief, and was chiefly intended to instruct mariners in the use of the chart. Halley points out that in certain regions where the "Curves" run suitably they may be used "to estimate the Longitude at Sea thereby." To his lines of equal "magnetic variation" he gave no distinctive name, simply referring to them as the "Curve Lines." Thus he says: "What is here properly New is the Curve Lines drawn over the several Seas to show the degrees of the Variation of the Magnetical Needle or Sea Compass." He does, however, use the term "Line of No Variation." For some time these lines were referred to by others as the "Halleyan lines." Hansteen a century later introduced the term "isogonic lines," which is now generally adopted. According to Hellmann, there is reason for believing that some attempts had been made before those of Halley to give on a globe or map a graphical representation of the direction in which a compass needle points. It is conceded, however, that Halley's was the first successful attempt; his "variation chart" was the first magnetic chart based on sufficient observational data to give it immediately both practical and scientific value.[3]

After the publication of his chart—the most important contribution to the observation material of terrestrial magnetism at the time—Halley made no further attempt to establish a theory or to improve on his early magnetic speculations. He appears finally to have adopted the view so clearly formulated by Prof. Turner[4]—"that the perception of the need for observations, the faith that something will come of them, and the skill and energy to act on that faith—that these qualities, all of which are possessed by any observer worthy the name, have at least as much to do with the advance of science as the formulation of a theory, even of a correct theory."

We find Halley embracing every occasion—"to recommend to all Masters of Ships and all others, Lovers of Natural Truths, that they use their utmost Diligence to make, or procure to be made, Observations of these Variations in all parts of the World, and that they please to communicate them to the Royal Society in order to leave as compleat a History as may be to those that are hereafter to compare all together and to compleat and perfect this abstruse Theory."

Consulting the minutes of the Royal Society, it is found that Halley communicated, from time to time, the results of magnetic observations received from various expeditions, as also the values of the magnetic declination observed by himself, at London, viz:

"1701, May 7.—Mr. Halley tried the experiment of the Variation of the Needle this day with the two needles he had with him in his late Voyage; and by the one the Variation was 7 deg. 40 min.; by the other, 8 deg. 00 min. W.

"1702, July 8.—Mr. Halley observed the Variation of the Needle, which was found to be 8½ deg. Westward, or very near it..

*Abstracts from the fourth "Halley lecture," delivered in the schools of the University of Oxford on May 22nd, 1913; illustrated by lantern slides. Reprinted, after revision by the author, and with added illustrations, from *Bedrock*, vol. 2, No. 3, October, 1913, pp. 273-294. *Smithsonian Report* for 1913.

[1]Valuable magnetic data have been secured by various expeditions since Halley's time, but either the magnetic work was merely incidental or formed part of a general scientific programme, or was combined with some geographical object such as Arctic or Antarctic exploration—the memorable "Erebus" and "Terror" expeditions, for example.

[2]Those interested in the history of the Halley charts may be referred to the various articles by L. A. Bauer, in *Nature*, May 23, 1895, p. 79, and in *Terrestrial Magnetism*, January, 1896, and September, 1913. The last-named reference also contains a compilation by J. P. Ault and W. F. Wallis of the magnetic results obtained on Halley's expedition.

[3]Mountaine and Dodson, the authors of the second and revised edition (1744) of the Halley Chart, and of the third (1756), published in connection with the latter a small tract, "An account of the Methods used to describe Lines on Dr. Halley's Chart of the terraqueous Globe, showing the variation of the magnetic needle about the year 1756 in all the known seas, London, 1758, 4 degrees." This tract was again published in 1784.

[4]Pres. Address, Sec. A, Brit. Assoc. Adv. Sci., 1911.

"1716, May 24.—Dr. Halley reported that he had drawn a Meridian Line on the stone erected in the Society yard before the repository and that the Variation was found at present to be full twelve degrees."

These observations of the magnetic declination of 1701, 1702 and 1716 are perhaps printed here for the first time and are not found in any compilations of magnetic declinations at London published thus far. Only Halley's earlier observations, namely, those of 1672 (2 deg. 30 min. W.), 1683 (4 deg. 30 min. W.), and of 1692 (6 deg. 00 min. W.), having been given by Halley himself in his printed papers of 1683 and 1692, have become known to compilers.

CHANGE OF THE MAGNETIC DECLINATION IN THE ATLANTIC OCEAN SINCE HALLEY'S CHART.

In view of the fact that the two vessels—the "Paramour" and the "Carnegie," both being primarily dependent for their motive power upon the prevailing winds in the Atlantic Ocean—have followed nearly identical courses, it will be a matter of no little interest to compare the values of the magnetic declination given on Halley's chart for 1700 with those obtained by the "Carnegie" in her cruises in 1909-1910. We find first that over the entire Atlantic, from 50 deg. N. to 40 deg. S., the north end of the compass needle in 1910 was to the west of the compass direction of 1700 by amounts varying with locality. Thus for various important ports the approximate change was as follows: New York, 2.9 deg. W.; St. Johns, Newfoundland, 14.6 deg. W.; Falmouth, England, 10.4 deg. W.; Funchal, Madeira, 15.6 deg. W.; Bermuda, 10.5 deg. W.; Porto Rico, 7.6 deg. W.; Para, Brazil, 14.6 deg. W.; Rio de Janeiro, 20.8 deg. W.; Buenos Aires, 13.0 deg. W.; Cape Town, 16.2 deg. W.

If we follow a line passing through the points of maximum change in the Atlantic Ocean, we find for the following points:

Values of the magnetic declination in 1700 and 1910.

Latitude.	Longitude.	Paramour Pink, 1700.	Carnegie, 1910.	Secular change (1910-1700).
50°.4 N.	30°.4 W.	11°.3 W.	29°.5 W.	18°.2 W.
35°.9 N.	47°.0 W.	4°.0 W.	22°.1 W.	18°.1 W.
21°.9 N.	39°.9 W.	0°.4 W.	19°.2 W.	18°.8 W.
3°.9 N.	33°.3 W.	2°.3 E.	16°.5 W.	19°.0 W.
40°.6 S.	25°.2 W.	10°.7 E.	17°.5 W.	28°.2 W.

We see, accordingly, that the compass direction, in the course of time, suffers large changes; for the region and time interval considered the changes vary from about 3 degrees off New York to 28 degrees in the Atlantic Ocean about midway between Buenos Aires and Cape Town. Even these amounts may not represent the total or maximum change during the period in question.

Equally to be noted with these large changes with time is the important fact that the amount of change is as dependent upon locality as is the prevailing compass direction itself, which for over four centuries has been known to be anything but "true to the pole."

We have thus had impressed upon us this important fact: Two sailing vessels cruising in the Atlantic Ocean from port to port—the one in 1700 and the other in 1910—were forced by the prevailing winds to follow very closely identical courses. If, however, these two vessels had been directed to follow certain definite magnetic courses, and if we may suppose that they had such motive power as to render them independent of the winds, then their respective paths would have diverged considerably. For example, if the "Carnegie" had set out from St. Johns, Newfoundland, to follow the same magnetic courses as those of the "Paramour," instead of coming to anchor in Falmouth Harbor, she would have made a landfall somewhere on the northwest coast of Scotland. In brief, while the sailing directions as governed by the winds over the Atlantic Ocean are the same now as they were during Halley's time, the magnetic directions or bearings of the compass that a vessel must follow to reach a given port have greatly altered. To quote from the suggestive essay on terrestrial magnetism by John F. W. Herschel:[1]

"The configuration of our globe—the distribution of temperature in its interior, the tides and currents of the ocean, the general course of winds and the affections of climate—whatever slow changes may be induced in them by those revolutions which geology traces—yet remain for thousands of years appreciably constant. The monsoon, which favors or opposes the progress of the steamer along the Red Sea, is the same which wafted to and fro the ships of Solomon. Eternal snows occupy the same regions and whiten the same mountains, and springs well forth at the same elevated temperature, from the same sources, now as in the earliest recorded history. But the magnetic state of our globe is one of swift and ceaseless change. A few years suffice to alter materially and the lapse of half a century or a century to obliterate and completely remodel the form and situation of those lines on its surface which geometers have supposed to be drawn in order to give a general and graphical view of the direction and intensity of the magnetic forces at any given epoch."

COMPLEXITY OF THE EARTH'S MAGNETISM.

Reference has already been made to Halley's attempts, before his magnetic expedition, to establish a theory

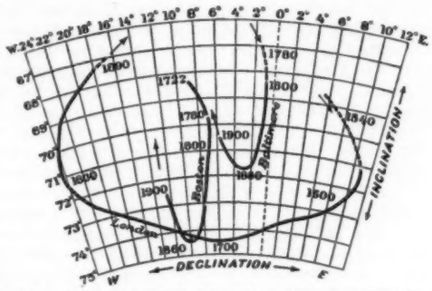


Fig. 1.—Curves showing the secular change in the Magnetic Declination and in the dip at London, Boston, and Baltimore

[Drawn for supposed length of freely suspended magnetic needle of about 50 centimeters, or nearly 20 inches]

respecting the phenomena of the compass needle. Thus in 1683 he published in the Philosophical Transactions of the Royal Society "A Theory of the Variation of the Magnetical Compass," and in 1692, in the same Transactions, "An Account of the Cause of the Change of the Variation of the Magnetic Needle."

In these papers Halley rejected the hypothesis which had been accepted up to that time, and on the basis of which elaborate tables of the magnetic declination had been constructed by previous investigators, namely, that the directions assumed by a compass needle in various parts of the earth could be accounted for by a simple magnetization parallel to a diameter so that

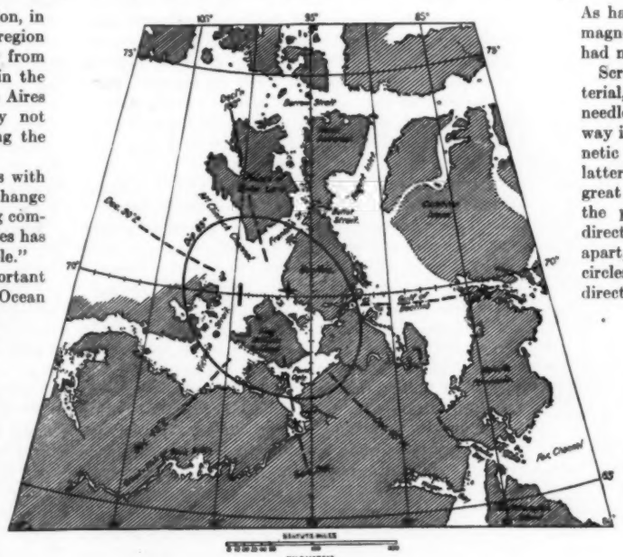


Fig. 2.—Map of region about the magnetic north pole, indicating how the compass points in the vicinity

[The earth's magnetic poles are on the average, 1,200 miles distant from the geographical poles.]

the magnetic poles would be diametrically opposite to each other. While the conclusion reached by him that "the whole Globe of the Earth is one great Magnet having four Magnetical Poles, or Points of Attraction, near each Pole of the Equator Two," has, in a certain sense, been found to be incorrect, nevertheless, this view appears to have been the first definite recognition of the heterogeneity or complexity of the earth's magnetic condition.

The increased knowledge gained from magnetic surveys since Halley's time has taught that the more carefully a country has been explored, i. e., the nearer together the points at which the magnetic elements have been determined, the greater is the number of irregularities usually shown by the so-called isomagnetic lines; indeed, regions have been found where no system of lines can adequately and correctly represent the prevailing magnetic conditions. We have learned that the regularities in the distribution of the earth's magnetism, far from being normal features, as was once thought, are, instead, the abnormal ones, and that the irregularities are the normal and to-be-expected phenomena.

The magnetic forces, as measured at any given point on the earth's surface, appear, according to various analyses, to be the resultant effects of (1) a general or terrestrial magnetic field due to the general magnetic condition of the whole earth; (2) a general terrestrial disturbing cause which distorts at the place of observation the general magnetic condition of the earth; (3) a disturbing effect continental in extent; (4) a regional disturbance effect due to low-lying magnetized substances; and (5) a local disturbance due to the magnetized masses in the immediate vicinity.

No formula has as yet been established which will represent the observational facts within the error of observation, in fact not even with sufficient accuracy for the practical purposes of the surveyor and of the mariner.

THE EARTH'S MAGNETIC POLES.

We have noticed that Halley, as the result of his study of the observations of the magnetic declination, as far as they had become known up to 1683, reached the conclusion that the earth had "four Magnetical Poles or Points of Attraction." Some confusion has arisen as to the precise meaning which Halley attached to his "poles." Owing to his alternative term—"Points of Attraction"—certain eminent writers have sought to identify Halley's supposed four magnetic poles with four foci of maximum total magnetic force, whose existence appeared to be indicated when, near the middle of the nineteenth century, it became possible to construct a chart of the lines of equal magnetic force. By this incorrect inference these authors have unwittingly credited Halley with a discovery which, in the absence at the time of any observation whatsoever respecting the strength of the earth's magnetic force, he could not possibly have made. The real merit and purport of Halley's deduction has thereby been obscured. The observation material at Halley's disposal, before he himself enriched the material during his voyages, consisted of some miscellaneous observations of the compass direction and a few values of the magnetic dip.

As has been said, there were no observations of the magnetic force, for the art of measuring this element had not yet become known.

Scrutinizing carefully his scanty observation material, Halley noticed that the direction of the compass needle did not change from place to place in the simple way it would if, for example, the earth had two magnetic poles diametrically opposite each other. In the latter case the needle would set itself tangent to the great circle passing through the magnetic poles and the place of observation. If, then, the compass direction were known at two places sufficiently far apart, the points of intersection of the two great circles drawn respectively tangent to these compass directions would be the two diametrically opposite magnetic poles. It is such points of intersection—"points of convergence" as Hansteen later called them—which Halley had in mind as "Magnetic Poles." He was the first to perceive clearly the fact—abundantly verified since—that the various points of convergence as found from successive pairs of compass directions, in the manner just described, do not fall together as they should on the basis of a simple or regular magnetization of the earth. However, it appeared to Halley, and the same conclusion was reached over 100 years later by the illustrious Norwegian magnetician, Hansteen, that the several points of convergence grouped themselves in a general way about two main centers—

"near each Pole of the Equator Two, and that in those parts of the World which lie near adjacent to any one of those Magnetical Poles the Needle is govern'd thereby, the nearest Pole being always predominant over the more remote."

It will not be well to lay greater stress upon this deduction nor upon those in his 1692 paper, where he seeks to account for the existence of his four "Magnetic Poles" and for the secular variation than to say that Halley drew the best possible conclusions the material at his disposal permitted. In fact, his conclusions were not materially improved upon until a century and a half later, when a much more complete knowledge of the distribution of the earth's magnetism had been gained and when the various mathematical attempts which had been made to compute the magnetic elements on the basis of more or less intricate hypotheses as to

[1] Essays from the *Edinburgh* and *Quarterly Reviews*, with addresses and other pieces, by Sir John F. W. Herschel, London, 1857, pp. 69-70.

the earth's magnetization, had been found to be inadequate. Some later investigators, indeed, might have spared themselves considerable pains had they previously familiarized themselves more thoroughly with Halley's work.

When we to-day speak of the earth's magnetic poles, it is generally recognized that those points on the earth's surface are meant where the dipping needle stands precisely vertical and where the magnetic dip is accordingly 90 degrees. This definition permits, with the aid of the dipping needle, of a precise determination of the magnetic poles, though, of course, it must not be understood that these poles are mathematical points; the area over which the dip may be found to be 90 degrees, within the instrumental means of determination, may, in fact, be several miles square. A more or less extensive magnetic survey of the region round about would be required to eliminate the possibility of disturbing influences owing to local deposits of iron ore. At these "Poles," since the magnetic force exerted by the earth is all up and down, with no side component, a compass needle would have no directive force acting upon it. Some distance before reaching the magnetic pole it would become sluggish, and directly over the pole itself it would be of no more use than a brass needle to indicate any definite direction.

Excluding for the present the purely "local magnetic poles," caused by extraordinary local deposits of attracting masses, all observations to date show that there are but two such points (or areas) where the dipping needle stands vertical, one in the Northern Hemisphere, located by Capt. James Clark Ross in June, 1831, in latitude 70.1 deg. north and longitude 96.8 deg. west (Fig. 3), and the other in the Southern Hemisphere, lying, according to the observations of the recent Antarctic expedition, about in latitude 72.7 deg. south and longitude 156 deg. east.[a] The magnetic poles, therefore, are, on the average, about 1,200 miles from the geographical poles. Owing to the asymmetrical distribution of the earth's magnetism, the magnetic poles are not diametrically opposite each other, even if the positions given applied to the same year; in fact, the perpendicular distance from the earth's center to the chord connecting the magnetic poles is about 750 miles.

Let us suppose, now, that one explorer starts out from Oxford, where the compass points at present about 16 deg. west, and follows always the direction shown by the north end of the compass needle, whereas another starts north from Washington, where the compass bears about 5 deg. west, and follows likewise the direction of the compass needle. The paths thus traced out by them are the so-called "magnetic meridians," which, owing to the irregular way in which the earth is magnetized, would not be straight lines or arcs of great circles, but more or less devious lines. Could these magnetic meridians be followed into the Arctic regions, they would be found to intersect at the north magnetic pole.

Owing to the irregular distribution of the earth's magnetism, the points of greatest intensity of the total magnetic force depart widely in their locations from the magnetic poles. Thus there are in the Northern Hemisphere two distinct maxima of total magnetic force, one in the northeast of Siberia and the other in Canada to the southwest, approximately, of Hudson Bay. A magnetic survey of the latter region is being made this summer by an expedition sent out by the Department of Terrestrial Magnetism.

DO THE MAGNETIC POLES MOVE?

Possibly the most frequent question asked of those engaged in magnetic work is: "Do the magnetic poles move with the lapse of years, and if so, why?" Unfortunately, as has already been shown, there are no direct observations as yet on which to base a definite statement. But it would be singular, indeed, if these points remained fixed and were not affected by fluctuations such as are now known from three centuries of observations to exist in every one of the earth's magnetic phenomena. It is quite possible, in fact, that the magnetic poles pass through certain motions even in the course of a day or suffer displacements during magnetic storms.

The diagram (Fig. 2) shows the changes in the direction of the compass (magnetic declination), as well as in the direction of the dip needle (magnetic inclination), as far as known, for London, Baltimore, and Boston. Imagine yourself, if you will, standing at the center of a great magnetized needle so suspended as to be free to assume the direction actually taken by the lines of magnetic force at the place of observation, and let us suppose you are looking toward the north-pointing end of the needle. Could you gaze long enough, you would see a curve described in space by the observed end of the needle. This curve would lie on a sphere whose radius is the half-length of the suspended needle and for graphical representation we may take a central projection of it on a plane tangent to the sphere at about the middle point of the curve. The curves here given were constructed by me with the aid of the accumulated observations up to about 1895; the course followed by the needle since 1895 will be discussed later. (Fig. 2.)

A number of interesting and instructive facts follow from these curves; time will permit us to give our attention only to the chief ones. It is seen that at London, for example, the compass reached its maximum easterly direction of about 11 degrees in the year 1580, hence during the middle of Queen Elizabeth's reign; thereafter the easterly direction began to diminish until about 1658, the year of Cromwell's death, when the needle bore due north and then swung over to the west, continuing to do so until it reached a maximum westerly direction of somewhat over 24 degrees in about 1812. Hence in the interval of about 232 years (1580-1812) the compass direction changed at London from 11 deg. E. to 24 deg. W., or 35 degrees. At the present time it points about 15½ deg. W., or nearly 9 degrees less than in 1812, and a most interesting question doubtless immediately occurs to all of us: Will the freely suspended magnetic needle ever return precisely to a direction taken at some previous time, or is there any definite cycle of changes which will repeat itself from time to time?

Here again no wholly definite answer can be given, primarily because of the fact, as will be seen from the diagram, that, if there be such a cycle, it embraces many more years than are covered thus far by the interval of observation. For some European stations, e. g., Paris and Rome, the observation interval is somewhat longer than at London, but still not long enough for definite prediction as to the future course of the magnetic needle.

The diagram shows also that in the United States the changes in the compass direction, as far back as they are known, have not been as great as those during the same time at London. Thus, at Baltimore, for example, the compass appears to have reached a maximum westerly amount of about 6.1 degrees near 1670, and a minimum of ⅔ degrees in 1802, after which, instead of passing through a zero value as at London in 1658, and swinging to the eastward, it turned back and began to increase its westerly direction until at the present time the amount is about 6½ degrees. Thus, at this station the compass direction passed from a maximum to a minimum in about 132 years and the total change was but 5½ degrees, or only one sixth to one seventh of that at London.

In brief, the facts revealed by the known compass changes in my country can not be brought in harmony with those witnessed in your country, unless we assume that the length of the cycle of complete change is many times longer than merely twice the period between a maximum and a minimum bearing of the compass. There are evidences furthermore, into which we can not go here, to indicate that the cycle of change at one station is not of the type which would result were we to close the apparently nearly completed curve at London by uniting the two ends in some simple manner. On the contrary, the evidences point to cycles within cycles and to the probability that the secular variation curve, instead of being a single closed curve, may consist of smaller loops within a larger one, etc.; it is even questionable whether there ever will be exact closure of the curve.

There is at present another matter of no little interest with regard to England which should be pointed out here. It will be seen from the London curve that the dip of the needle below the horizon reached its maximum amount of 74.4 degrees in about 1688. At this time the compass changed its direction the maximum amount of 13 minutes per year. The curve would seem to indicate that the time of a minimum dip is now approaching; this phase has already occurred at Pawlowsk and seems to be now taking place at Potsdam and is traveling westward. Whether it will reach London and when can not be answered definitely. However, it is a matter of no little interest, in this connection, to observe that the annual amount of change in the compass direction has in recent years received a remarkable acceleration in this part of the earth. Thus, as is shown by the magnetic observatory records, it has almost steadily risen from 4 minutes per year in 1902 to about 9 minutes per year in 1912. Whether this portends an early approach of the phase of minimum dip at London is one of the many interesting questions continually arising respecting the perplexing phenomena of the earth's magnetism. The course of the needle since 1890 has been about as shown by the arrow; thus in 910 the magnetic declination was approximately 15.9 deg. W. and the dip was 66.9 degrees.

One thing more. Note that for each of the three curves as far as drawn, the motion of the freely suspended magnetic needle has been clockwise, i. e., the same as the motion of the hands of a watch. This fact, as shown by the curves in other parts of the world, constructed with the aid of the available observations, appears to hold generally in both the Northern and Southern Hemispheres, except for certain retrograde motions which thus far have not been of the same extent as the direct one, although, of course, it is not affirmed that they may not become so later. Such retrograde motions are at present being experienced in certain parts of the United States. Thus, for example, the compass pointed in 1910 6.25 deg. W. at Baltimore and 13.35 W. at Boston, and in the same year the magnetic dip was 70.9 at Baltimore and 73.1 at Boston. If we plot these values on the diagram, we shall find that the curves for Boston and Baltimore, instead of progressing in the direction of the arrows, passed through a secondary crest about 1895 and then bent over to the left; how long this will continue can not be foretold.

The question as to the cause of the remarkable change from time to time in the earth's magnetic condition, as indicated by these curves, has been a fruitful source of speculation since 1634, when Gellibrand definitely proved the fact that the compass direction varies from year to year. Some of the best minds have been engaged with the discovery of the cause, but the riddle is still unsolved. Hence as regards the actual motions of the earth's magnetic poles and the precise cause or causes, we may still say with Halley that these are "Secrets as yet utterly unknown to Mankind, and are reserv'd for the Industry of future Ages."

A mathematical analysis of the accumulated material shows that, in order to find an adequate explanation of the secular variation of the earth's magnetism, we must reckon with systems of magnetic or electric forces having their seats both below and above the earth's crust. There would also appear to be some evidence that in addition to a motion of the magnetic poles or magnetic axes of the earth, we may also have to take into account a possible diminution in the earth's magnetic moment or intensity of magnetization.

THE ORIGIN OF THE EARTH'S MAGNETISM.

Before concluding this lecture, we ought, perhaps, in the few minutes remaining, to say something regarding the status of the ever-recurring question as to the origin of the earth's magnetism. Assuming that the magnetism of our planet is uniformly distributed throughout its mass, it is found that the average intensity of magnetization is only about one ten thousandth that of very highly magnetized hard steel. Prof. Fleming, in his very suggestive popular lecture on the "Earth, a great magnet," given at the meeting in 1906 of the British Association for the Advancement of Science, made this statement:

"Taken as a whole, the earth is a feeble magnet. If our globe were wholly made of steel and magnetized as highly as an ordinary steel-bar magnet, the magnetic forces at its surface would be at least 100 times as great as they are now. That might be an advantage or a very great disadvantage."

If, however, we could penetrate the earth's crust we would find at a distance of only about twelve miles a temperature so great that, according to present laboratory facts, all magnetizations would necessarily cease. Hence, if the earth's magnetic field arises from an actual magnetization of the substances composing the earth, these substances must be confined within a comparatively thin shell. But the question immediately arises: Is this argument correct? May it not be that just as the point of liquefaction is raised by increased pressure, so is also the critical temperature of magnetization. It may thus occur that the effect due to increase of pressure with depth of penetration more than balances that due to increased temperature. There are at present no wholly decisive experiments which may be drawn upon to answer this query.

The hypothesis that the earth may be an electromagnet also meets with difficulties when we attempt to account for the origin, direction, and maintenance of the required currents. In spite of the accumulated facts of over three centuries, we are still unable to say definitely to what the earth's magnetic field is really due. Perhaps we may not be able to solve the riddle until the physicist answers for us the questions: What is a magnet? What is magnetism in general?

In the Devil's Dictionary by Ambrose Bierce, published in 1911, the following definitions are given: Magnet, n.—Something acted upon by magnetism. Mag-

[a] A local magnetic North Pole was disclosed by the observations of Bauer in 1900 and 1907 at Treadwell Point, near Juneau, Alaska. Ships' compasses a mile away, in Gastineaux Channel, are deflected about 11 degrees.

netism, n.—Something acting upon a magnet." In explanation the author cynically remarks: "The two definitions immediately foregoing are condensed from the works of 1,000 eminent scientists, who have illuminated the subject with a great white light, to the inexpressible advancement of human knowledge."

A line of thought first suggested by Schuster and Lord Kelvin, that every large rotating mass, due to an as yet undiscovered cause, may be a magnet, should be considered in conclusion, though we may do so but briefly. If this be true, then magnetism is not confined to our planet alone, but all celestial bodies are surrounded by magnetic fields. Thus far no laboratory experiment, possibly owing to lack of required sensitiveness in the measuring instruments, has detected any magnetic field arising solely from rotation. Schuster and Swann have recently discussed the character and magnitude of the effects from the possible causes which may operate if the earth's magnetic field be related in some manner to its rotation.

In 1900-1903 Sutherland propounded a theory for the origin of the earth's magnetism, which, briefly stated, is this: We know that electricity is an essential constituent of matter, and that in every atom, if it be electrically neutral, there are equal amounts of negative and positive electricity. So with the whole earth. Since it is almost electrically neutral, suppose that the total negative charge, while practically equal to the total positive one, occupies a slightly different volume from that of the positive charge, or, in brief, that the volume densities of the two body charges differ slightly, then, because of the rotation of the electric charges with the earth, a magnetic field arises. I have recently repeated Sutherland's calculations and, as I had previously found that the earth's intensity of magnetization increased systematically toward the Equator, I have included a term to represent such a possible effect. The computations show that to satisfy the known phenomena of the earth's magnetism the volume density of the negative charge must be smaller than that of the positive, or, in other words, the earth's total negative charge must be distributed through the larger sphere, and, if that be the whole earth itself, then for the chief term involved in the magnetic potential, the surface of the sphere containing the positive charge need be, on the average, only 0.4×10^{-3} centimeters, i. e., four tenths of the radius of an ordinary molecule, below that of the earth's surface to give a magnetic field of the required strength. Taking the average atomic weight of the earth's substance in round numbers as 50, the mean volume density of either charge would be about 3.3×10^{-12} electrostatic units.

At present there is little hope that a magnetic field, caused just as supposed, can be detected in the laboratory. For a sphere of fifteen centimeters radius, rotating one hundred times a second, the magnetic intensity at the poles would be but one hundred millionth part (10^{-8}) of that of the earth. We thus see that the quantities involved in the solution of one of the great problems confronting the student of the earth's physics —the origin of the earth's magnetic field—may be of such a minute order as to be beyond the ken at present of the laboratory experimentalist. Perhaps the effects become appreciable in the case of the earth because of the fortunate fact that it is a body of sufficient size and angular velocity.

On the other hand, the geophysicist is at a great disadvantage in that he is unable to bring his earth-magnet into the laboratory and to experiment upon it—to reverse the direction of rotation, for example, and see what would happen! Fortunately for him, however, nature comes to his relief somewhat and performs experiments for him on his great magnet on a world-wide scale, by producing in an incredibly short time manifold and at times startling variations and fluctuations in the apparently fixed magnetization of the earth. Thus, on September 25th, 1909, there occurred the most remarkable magnetic storm on record, during which, within a few minutes, the earth's magnetic movement, or intensity of magnetization, was altered by about one twentieth to one thirtieth part. The earth's magnetic condition was below par for fully three months thereafter. As this severe storm was accompanied by a brilliant display of polar lights, this is the most appropriate place to recall that Halley made the first suggestion of a connection between the aurora borealis and the earth's magnetism.

It is firmly believed that a long step forward will have been taken toward the discovery of the origin of the earth's magnetism when once we have found out what causes it to vary in the surprising manner shown by the secular or long-period changes, by the magnetic storms, and the numerous other fluctuations, such as the diurnal variation, for example. The keynote of modern investigation in terrestrial magnetism, as in the biological sciences, must surely be the study of the variations and mutations!

Is it not probable that the very features of the earth's magnetism regarded at one time as defects—the "constant inconstancies," as an early writer quaintly put it—will instead become sources of help and inspiration from totally different points of view or in some entirely different line of thought? Who knows of what import the riddles of the earth's magnetism, characterized by eminent physicists as being, next to gravity, the most puzzling of natural forces, may be, not simply to the magnetician alone, but to all interested in the steady progress of the physical sciences? Thus Schuster suggests that "atmospheric electricity and terrestrial magnetism, treated too long as isolated phenomena, may give us hints on hitherto unknown properties of matter." "The field of investigation into which we are introduced," says Maxwell, "by the study of terrestrial magnetism, is as profound as it is extensive." And, says Sabine, one of England's greatest and most enthusiastic magneticians, "Viewed in itself and its various relations, the magnetism of the earth can not be counted less than one of the most important branches of the physical history of the planet we inhabit."

[1] These definitions and accompanying remarks may have had their origin in the following interesting anecdote told in the *American Review of Reviews* for August, 1909, of the late Prof. Simon Newcomb, by Mr. A. E. Bostwick, associate editor of the Standard Dictionary. Of the definitions in physical science for this dictionary Newcomb had general oversight, and on one occasion he took exception to the definitions framed for the words "magnet" and "magnetism" as based, in the absence of authoritative knowledge of the causes, simply upon the properties manifested by the things. After writing and erasing alternately for an hour or more, he finally confessed, however, with a hearty laugh, that he himself could offer nothing better than the following pair of definitions: "Magnet, a body capable of exerting force; and magnetic force, the force exerted by a magnet."

The Third War Wine Harvest

In their annual report on the world's grape harvest Messrs. W. and A. Gilbey state that although there has always been an intelligent interest taken in this country in the annual grape gathering of the world, it would not have been at all surprising if it had diminished in this, the third vintage of the war, when the consumption of wine with us—always so very limited as compared with that of other nations—has still further declined, and now stands at the lowest level since the reduction of duties in 1860. On the military importance of wine it is remarked that France has already requisitioned for her military needs the astonishing total of some 200,000,000 gallons of this year's wine (representing one-fifth of her own entire annual production), as well as more than 40,000,000 gallons from her Algerian colony, and storage has already been arranged for this enormous volume of wine, representing in value no less than £20,000,000. by the taking over of special warehouse accommodation in every department of France. So essential is the regular supply of pure wine considered for the well-being of the troops that similar exceptional precautions are being taken to safeguard the 1916 crop in Italy, not only for her soldiers serving at the front, but also for their sick and wounded comrades in the hospitals.

In our preliminary report of August last on the favorable prospects of this year's vintage in France, we felt justified (continue Messrs Gilbey), in face of the ideal weather experienced up to that time, and the consequently exceptionally healthy appearance of the vineyards, in assuming that there would be a full average crop of over a thousand million gallons of wine made in France this year. There are circumstances, however, which now point to a somewhat diminished production. In the more northern parts of France, the vineyards of which, although comparatively small in area, include the valuable Champagne districts round Reims and Epernay, the crop has been unfortunately well-nigh destroyed, and instead of a normal yield of this popular beverage there will only be a meager quantity of grapes gathered; while the quality will be such that the juice will scarcely be worthy of being converted into sparkling wine. The Champagne vintage of 1916, therefore, must, in contrast with that of most other parts of France, be pronounced a failure. In most of the other central and southern vinelands of France, however, where the great bulk of the wine is produced, there can be no doubt that, if the quantity is not quite so large as was anticipated, the quality is excellent.

In the Bordeaux district, whence are obtained all the famous clarets that are known in England, the vineyards had not presented such a magnificent appearance for many years. It is true that the bunches are not quite so large as in some years, but every berry had reached a perfect degree of ripeness, and the proportion of saccharine is exactly what is looked for in the finest clarets. There is little doubt that the clarets, not only of the numberless famous growths from Château Margaux and Lafite to Léoville and Pontet Canet, but even the Bourgeois and Paysan wines of the Médoc will be of rare excellence. There will be a large quantity of red burgundy of the cheaper descriptions made this year, but owing to their being produced in the low-lying lands it is not expected that the quality will rank high. The more reputed vineyards of the Côte d'Or—Pommard, Volnay, Beaune, Corton, including the famous growths of Chambertin, Romanée, Richebourg and Clos de Vougeot —will, owing to the exceptionally fine weather throughout, and particularly during three or four weeks preceding the gathering, have produced some excellent specimens of these full-bodied natural red wines of France. Much attention is being paid at present to the displacement of the German wine trade, and a large variety of French, white wines will no doubt be brought under the notice of the British public during the next few years under the names of the localities where they are produced.

There is no doubt that the next few days will witness the development of a considerable commerce in both still white and sparkling French wines other than champagnes which, except for the present war, would not have been brought to the notice of the British public. Although the quantities of these French wines made this vintage will not be so large as was anticipated a few weeks ago, there will be, nevertheless, a considerable total production in 1916 and in the future, and the remarkably fine quality of the wines will go far to assure during the next few years the transferring of much of the erstwhile wine trade of Germany to France. Meanwhile, the ordinary trade in the white wines of France will receive an additional impetus owing to the exceptionally fine quality of this year's yield of the varieties already so well known, viz., the Sauterine and Graves, wines of the Bordeaux districts and the Chablis of the Burgundy districts, all of which are of exceptionally fine quality this vintage. Particularly is this the case in regard to the growths of sauterne.

The cognac district, which embraces the two Charentes, has enjoyed all the early and late fine weather of the claret districts of the Médoc. The wine will, therefore, be of excellent quality, if somewhat under the average in quantity. A good and abundant vintage from Italy and Sicily, except in a few regions, is assured, and a good average crop of about 14,000 butts has been harvested in Madeira.—*The London Daily Telegraph.*

Audible Reception of Cable Messages Possible

The War Department has announced as the result of a number of experiments performed under working conditions on the Pacific Coast under the direction of Lieut.-Col. George O. Squier, U. S. A., the discovery of a means whereby cable communication may be received by ear instead of by eye as at present. The official announcement regarding the invention follows in part:

"The preliminary experiments, which have been in progress for some months, were made at the government radio laboratories, and the actual tests on an ocean cable have been completed recently. The improvement consists essentially in the adaptation of the 'ticker' and audion types of instrument used for receiving the signals in radio telegraphy.

"The tests have been made on the Government Signal Corps cable from Sitka, Alaska, to Seattle, Wash., and the receiving apparatus was installed in the Seattle office. This cable is 1086 miles in length and has a K. R. approximately equivalent to one of the Atlantic cables.

"The actual receiver is an ordinary telephone. The feeble current received is normally inaudible in the telephone. It is broken up by means of a slipping contact 'ticker' and rendered audible. In order to secure greater sensibility, a tuned audion amplifier is used in connection with the ticker. The sensitiveness of this apparatus is so great that less than one-twentieth of the voltage necessary for operating the siphon recorder is sufficient to give good traffic signals.

"The significance of this development may be realized when we remember that at present all the traffic for ocean cables has to be translated into an entirely different code at each end and that highly paid cable readers are required to decipher these messages. The present discovery brings the operation of ocean cables in line with land line telegraphy as well as radio telegraphy. The increased sensitiveness obtained by this method guarantees the operation of ocean cables under conditions when they would be totally interrupted as at present used and forecasts radical improvements in the world engineering practice of cable telegraphy."

Racial Characteristics of Hair

From very early times a vigorous growth of hair has been held to be a sign of exceptional physical strength, as in the Biblical tale of Samson. Perhaps some such idea clings to the slang term "*poilus*," i. e., "hairies," applied to French soldiers.

Apropos of this idea that "hairies" must also be "huskies," Henri Coupin, writing in *La Nature*, observes: "It is amusing, in this regard, to remark that the most 'hairy' specimen of the human genus is—the new-born infant! In whom, however, strength and courage do not seem pre-eminent qualities. Man comes into the world, in fact, covered almost completely (save for the palms of the hands and the soles of the feet) with a soft down called by anatomists the *lanugo*. This is soon shed, and is replaced in the earliest infancy by definite hairs still almost entirely hidden in the skin. It is in only a few cases, entirely abnormal and exceptional, that this generalized pilosity persists and even increases later, either over the whole body—in the creatures called 'shaggies,' which are exhibits at country fairs—or merely on certain parts of the face, giving rise to 'dog-men' and 'bearded women.' These phenomena are not always of congenital origin, but even oftener do not appear till later, at the expense, then, of definite hairs. Certain women, indeed, do not acquire a beard till after their first youth, following an illness or during old age. This extreme pilosity of the new-born suggests that primitive man must have been covered with hair, and that this has little by little disappeared, in part, under many influences, among which it is quite possible that the development of the brain had a place—a veritable 'organic balancing,' of which there are so many examples in biology.[1]

"From the same philosophic point of view it may be remarked that there is no complete identity, as is somewhat wrongly claimed, between the disposition of the hairs on men and that of the anthropoid apes, with which some authorities place our ancestral origin. Among these apes, for example, the hairs of the arms are all directed upward, a fact probably due to the circumstances that they almost incessantly hold their arms over their heads, either to shelter themselves, as from rain, or in reaching for higher branches—and such disposition of the arms almost obliges the hairs to obey the laws of gravity—such disposition being transmitted by heredity.

"In man, on the contrary, the hairs are turned downwards toward the wrist in the upper half of the arm and almost transversely in its lower half.

"From the point of view of the pilary system man appears to have had multiple origins, according to the race under consideration. With reference to the racial varieties of hair we distinguish the principal kinds, straight, waved, curled and wooly. Straight hair is smooth, rectilinear, generally coarse and stiff, and falls more or less heavily in sheets down the sides of the head; good examples are the Chinese, Mongols and South American Indians.

"Waving hairs describe a curve or a spiral, more or less loose, sometimes rolling up at the end to form curls. This is a very wide-spread type among Europeans, the Veddas, the Todas, etc. Curly hairs describe many spiral turns, forming successive rings a centimeter or more in diameter; they are exhibited in Nubians, Australians, certain mulattoes.

"As for crisped or wooly hair, the spiral turns are very close together, and felt into each other in the manner of sheep's wool; sometimes, as among certain Melanesians and the majority of adult negroes, the suit of hair forms a continuous fleece, in consequence of the length of the hairs and the width of the spirals; sometimes, as among the Hottentots, the Bushmen, and the majority of young negroes, the hairs, being short and with very close spirals, form little tufts (known as pepper-grain hair), whose dimensions vary, and which are not due, as might be believed, to the absence of hairs in the interval spaces.

"The different kinds of hair differ not merely in aspect, but also in diameter, which also is maximum in the middle in all. If we cut them at the same level, which is indispensable for purposes of exact comparison, we see that straight hair has a circular section, while wooly hair presents a section in the form of an elongated ellipse; in waving hair the ellipse is more nearly circular.

"If we represent the long axis of the ellipse by 100, then the short axis will be as follows: Bushmen and Hottentots, 40 to 50; Negroes, 50 to 60; Esquimaux, 77; Tibetans, 80; Japanese, 85; Europeans, 62 to 72; etc. The hair of negroes is creped or wooly, both because its section is elliptical and also because it issues from a twisted follicle.

"Straight hair is the longest known; wooly hair the shortest. The length is almost the same in both sexes in certain races having straight hair (Chinese, Redskins), and also in the majority of races with curling hair; it is scarcely so among races with waving hair, in whom it is more or less manifestly longer in the female. The number of hairs is also very variable. A patient anatomist has counted 272 per square centimeter in a European, 252 to 286 in a Japanese, only 214 on the average in the Ainos, a race noted for its extreme pilosity. The number of hairs is also more numerous in the blond-haired than among the black-haired or brown-haired. For example, 147 black hairs, 162 brown hairs and 182 blond hairs per square inch.

"As for the beard and mustache, they are very unequally developed in the various human races. Among the Mongols and Malays there are only a few scanty hairs on the chin and at the corners of the mouth; and among negroes the beard never attains the same dimensions as in Europeans, among whom it is considered, according to the whims of the mode, now an impressive ornament, and now something to be suppressed by the razor. Most of our soldiers hold by the latter custom, and it is curious enough to note that in the modern army these faithful disciples of the razor are precisely those who have been dubbed '*poilus*.'"

[1] Let us recall, for the benefit of those who have some knowledge of embryology, that the brain is derived from the ectoderm, i. e., from the future skin.

The Nearest Star

The discovery of a star comparatively near to our sun is a matter of unusual interest. The southern star, Alpha Centauri, which is a bright star, has for so long been regarded as our nearest neighbor that to put another, and that a very small star, in its place requires some mental effort. Formerly it was a general assumption that a star appears bright because it is near to us; or in other words, that if stars could be examined at close quarters they would be found equally bright and equally large. This view, which at best was only an approximation, has been superseded, and a better criterion of the distance of a star has been found in the size of its apparent movement relative to the general body of stars. The determination of proper motion, generally by comparison of photographs, is now being carried on in various parts of the world, and in June last Professor Barnard, of the Yerkes Observatory, found this rapidly moving object in the constellation Ophiuchus. A sixth magnitude star, know as Groombridge 1830, which moves 7 seconds of arc a year, was formerly named the "Runaway"; later a southern star of magnitude 8, which moves nearly 9 seconds annually, was found; and now this small star, nearly two magnitudes fainter, which has been appropriately called "Gilpin" by the Yerkes Observatory staff, is known to move rather more than 10 seconds in each year.

Groombridge 1830 is not very near to us. The small southern star above-mentioned is one of the ten nearest, and inquiry naturally arose where the new discovery ranks in this respect. The determination of the distance, or parallax, of a star requires at least a year for its complete determination, for it is affected by comparing the apparent position of the star as seen from different points in the earth's orbit. Nevertheless, preliminary results have been deduced from observations available which are well worthy of consideration, the first published value of the parallax found in this way being half a second of arc. A later determination reached nearly three-quarters of a second, and another a whole second. These figures may appear discordant, but it seems justifiable to assume that the parallax is at least three-quarters of a second, which is that of Alpha Centauri, and corresponds to a distance of about twenty-five million million miles. If the parallax be found finally to be a whole second, this distance will be reduced to nineteen billion miles.

Though faint, the star has been examined with the spectroscope, and with this instrument it has been found that it is moving towards us at the rate of 90 kilometers a second. If the parallax is as large as a second, the actual velocity in space, thwartwise, or in the direction at right-angles to the line of sight, is 49 kilometers a second; but these velocities are not excessive, because Arcturus is said to be traveling at a rate of more than 200 miles in that short time. There is another record, however, that the small star in Ophiuchus does hold. Its absolute luminosity is computed to be one three-thousandth that of our sun, and it is therefore the faintest star so far known.—*The London Daily Telegraph.*

Metal Coated Foundry Patterns

For repetition work there is a great deal to be said in favor of the use of metal patterns in the foundry instead of the usual wooden variety, which must naturally have a shorter life than the metal type. The question to be considered is whether the extra cost of metal patterns will be covered by saving in wooden patterns that otherwise would be required. For exact work the metal pattern is undoubtedly superior, since, in addition to wearing less, it does not warp; on the other hand, it does not readily permit of changes in design.

It would seem that the merits of both types of pattern could be united if it were possible to treat the wooden patterns by a metal spray process. Experiments on these lines have recently been conducted, the coatings adopted being either of copper or lead, as required, such coatings being readily applied even to fragile and complicated wooden patterns. The metal coating is claimed to render the patterns waterproof and to increase their strength, so that they will hold their shape and more successfully resist the wear and tear incident to the moulding process. Experiments already made seem to show that these claims are well founded, and wooden patterns which have been coated, some with lead and some with copper, have given surprisingly satisfactory results. Subject to these experiments standing the test of time, it would seem that the scheme is one which might well be used where the cost of metal patterns is not warranted, and yet where, owing to extensive and hard usage, ordinary wooden patterns become expensive on account of the need of frequent renewals.

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Table of Contents

	PAGE
What Is a Disease?—By Charles Mercier	146
Reduction of Nitric Oxide by Contact Action of Metals and Metallic Oxides.—By Birendra Bhusan Adhikary	147
The Use of Iron by Primitive Man.—3 illustrations	148
Amateur Astronomical Photography.—By M. Thomas Fullan.—3 illustrations	149
New Railway Lines Projected in Russia	150
Tunneling Under a River	151
The Ancient Capitals of Lanka.—By Carl Stearns Clancy.—6 illustrations	153
How to Recognize Good Table Poultry	155
On the Correct Adjustment of Chemical Weights.—By William Crookes	156
How Waste Paper Is Used in Paper Mills	158
The Earth's Magnetism.—By L. A. Bauer.—3 illustrations	158
The Third War Wine Harvest	159
Racial Characteristics of Hair	160
The Nearest Star	160